

Draft Comparative Effectiveness Review

Number XX

Total Worker Health™ (TWH)

Prepared for:

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-based Practice Centers (EPCs), sponsors the development of systematic reviews to assist public- and private-sector organizations in their efforts to improve the quality of health care in the United States. These reviews provide comprehensive, science-based information on common, costly medical conditions, and new health care technologies and strategies.

Systematic reviews are the building blocks underlying evidence-based practice; they focus attention on the strength and limits of evidence from research studies about the effectiveness and safety of a clinical intervention. In the context of developing recommendations for practice, systematic reviews can help clarify whether assertions about the value of the intervention are based on strong evidence from clinical studies. For more information about AHRQ EPC systematic reviews, see www.effectivehealthcare.ahrq.gov/reference/purpose.cfm

AHRQ expects that these systematic reviews will be helpful to health plans, providers, purchasers, government programs, and the health care system as a whole. Transparency and stakeholder input are essential to the Effective Health Care Program. Please visit the Web site (www.effectivehealthcare.ahrq.gov) to see draft research questions and reports or to join an e-mail list to learn about new program products and opportunities for input.

If you have comments on this systematic review, they may be sent by mail to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 540 Gaither Road, Rockville, MD 20850, or by email to epc@ahrq.hhs.gov.

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Key Informants

In designing the study questions, the EPC consulted several Key Informants who represent the end-users of research. The EPC sought the Key Informant input on the priority areas for research and synthesis. Key Informants are not involved in the analysis of the evidence or the writing of the report. Therefore, in the end, study questions, design, methodological approaches, and/or conclusions do not necessarily represent the views of individual Key Informants.

Key Informants must disclose any financial conflicts of interest greater than \$10,000 and any other relevant business or professional conflicts of interest. Because of their role as end-users, individuals with potential conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any conflicts of interest.

The list of Key Informants who provided input to this report follows: To Be Added for Final Version

Technical Expert Panel

In designing the study questions and methodology at the outset of this report, the EPC consulted several technical and content experts. Broad expertise and perspectives were sought. Divergent and conflicted opinions are common and perceived as healthy scientific discourse that results in a thoughtful, relevant systematic review. Therefore, in the end, study questions, design, methodologic approaches, and/or conclusions do not necessarily represent the views of individual technical and content experts.

Technical Experts must disclose any financial conflicts of interest greater than \$10,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential conflicts of interest identified.

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Peer Reviewers

Prior to publication of the final evidence report, EPCs sought input from independent Peer Reviewers without financial conflicts of interest. However, the conclusions and synthesis of the scientific literature presented in this report does not necessarily represent the views of individual reviewers.

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Total Worker Health™ (TWH)

Structured Abstract

Objectives. The purpose of this review is to provide an evidence report that the National Institutes of Health, Office of Disease Prevention, Pathways to Prevention Workshop Program can use to inform a workshop focused on Total Worker Health™ (TWH). TWH is defined as a strategy integrating occupational safety and health (OSH) protection with health promotion (HP) to prevent worker injury and illness and to advance worker health and well-being. This review describes the body of evidence evaluating TWH interventions, assesses the benefits and harms of interventions, and highlights research gaps and future research needs.

Data Sources. We searched MEDLINE®, the Cochrane Library, the Cochrane Central Trials Registry, and PsycInfo from January 1, 1990, to March 26, 2015. Eligible studies included randomized controlled trials (RCTs), nonrandomized trials, prospective cohort studies with a concurrent control group; single group pre-post studies were also eligible for key questions (KQs) describing interventions or identifying contextual factors, research gaps, and future research needs.

Review Methods. Pairs of reviewers independently selected, extracted data from, and rated the risk of bias of relevant studies; they graded the strength of evidence (SOE) using established criteria. We synthesized all evidence qualitatively.

Results. We included 21 studies described in 28 publications. Twelve studies had a concurrent control group (10 RCTs, 1 nonrandomized trial and 1 cohort study) and were eligible for all KQs; 9 were pre-post studies. Studies were very heterogeneous in terms of work settings and populations, interventions, and outcomes. For the 12 studies eligible for KQ2, we rated 10 as high risk of bias primarily because of selection bias. Multicomponent integrated interventions were effective in improving rates of smoking cessation (7-day abstinence) at 22 to 26 weeks and fruit and vegetable consumption at 26 to 104 weeks (low SOE for both conclusions); these results apply to populations of blue-collar manufacturing and construction workers. Evidence was insufficient or completely lacking for other outcomes of interest (e.g., rates of occupational injuries, quality of life). Effective interventions were informed by worker participation and highlighted the potential synergistic risks of hazardous workplace exposures and health behavior. Work organization factors and union membership status were two commonly mentioned contextual factors that may have modified intervention effectiveness. Future studies should try to assess directly the effectiveness of integration itself by isolating the benefits (or harms) of integration from the effects of a new or improved HP or OSH component.

Conclusions. The body of evidence was small and diverse in terms of populations, interventions, and measured outcomes. TWH interventions were effective in improving rates of smoking cessation at 22 to 26 weeks and fruit and vegetable consumption at 26 to 104 weeks. Including a broader range of workers in future studies could increase the applicability of TWH interventions. Future research should be designed to isolate the effectiveness of integration from that for individual HP and OSH components.

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Executive Summary

Background

The American worksite has been a venue for both health protection and health promotion programs. Health protection programs are interventions aimed specifically at preventing occupational injuries or illnesses. Work-related injuries and illnesses lead to morbidity, mortality, and considerable financial and social costs.¹⁻³ Health promotion (HP) programs, often called wellness programs, are interventions aimed at improving modifiable behavior risk factors such as smoking, physical activity, and diet, which are leading causes of morbidity and mortality in the United States.⁴

Traditionally, occupational safety and health (OSH) programs and HP programs have functioned independently within the workplace.⁵ In the past decade, however, interest in integrating these programs has grown appreciably.⁵⁻⁷ The National Institute for Occupational Safety and Health (NIOSH) focused attention on integrated approaches in 2011 by creating the Total Worker Health™ (TWH) program. The rationale for integrating OSH and HP programs includes the following:⁸

- Workers' risk of disease is increased by exposures to both occupational hazards and modifiable risk-related factors for chronic disease.
- The workers at highest risk for exposure to hazardous working conditions are also those most likely to engage in risk-related health behaviors.
- Integrating OSH with worksite HP may increase program participation and effectiveness for high-risk workers.
- Integrating OSH with worksite HP may also benefit the broader work organization and environment.

TWH is the “strategic and operational coordination of policies, programs, and practices designed to simultaneously prevent work-related injuries and illnesses, and enhance overall workforce health and well-being.”⁹ TWH is a trademarked term that was not commonly used in past studies of integrated interventions. For this review, we use the term “TWH interventions” to refer to integrated interventions that are consistent with NIOSH’s TWH initiative. TWH interventions are often multicomponent interventions that pair organizational changes or policies with individualized content focused on a specific occupational hazard and one or more health behaviors or risk factors for chronic disease. For example, some programs focus on reducing or eliminating exposure to both tobacco and workplace chemicals;¹⁰ others aim to decrease musculoskeletal disorders and foster physical fitness at the individual and environmental levels;¹¹ and yet others attempt to integrate information about individual lifestyle and safety health behaviors to reduce occupational lead exposure.¹²

Rationale for Evidence Review

The goal of this review is to identify gaps in the evidence about TWH effectiveness to help identify future research priorities. This executive summary is based on the methods, data, conclusions, and appendices presented in the main report.

Previous reviews of the literature have differed in scope (i.e., used different search and inclusion criteria and addressed a narrower set of key questions), thereby including studies of varied rigor and scope.^{13,14} Moreover, the effectiveness of the interventions in individual studies and in the prior reviews has been judged based on various metrics (e.g., various improvements in

health behaviors, physiologic outcomes and economic outcomes, or a count of the number of significant outcomes). As a result, uncertainty remains about the benefit of TWH interventions for improving specific health and safety outcomes. These factors underscore the need for the current systematic review to synthesize the literature supporting TWH interventions, assess the strength of evidence for important outcomes, and highlight research gaps and future research needs.

Scope and Key Questions

The purpose of this review is to provide an evidence report that the National Institutes of Health (NIH), Office of Disease Prevention, Pathways to Prevention (P2P) Workshop Program can use to inform a workshop focused on TWH.¹⁵ This review will describe the body of evidence evaluating TWH interventions, assess the effectiveness of TWH interventions for improving health and safety outcomes, highlight the research gaps, and call out future research needs. The P2P Workshop Program Panel will use the evidence report as a resource to develop a summary of the current state of the science and future research needs related to TWH interventions. Specifically, we address the following six Key Questions (KQs):

Key Question 1

What populations, work settings, intervention types, and outcomes have been included in studies assessing integrated interventions?

Key Question 2

What is the effectiveness of integrated interventions for improving the following outcomes, and what are the potential harms?

- a. Health and safety outcomes (e.g., cardiovascular events or incidence of work-related injuries)
- b. Intermediate outcomes (e.g., change in blood pressure, tobacco use, or hazardous exposures)
- c. Utilization outcomes and occupational injury and illness surveillance outcomes (e.g., hospitalizations or measures of workers' compensation claims)
- d. Harms (e.g., discrimination or victim blaming).

Key Question 3

What are the characteristics of effective integrated interventions?

Key Question 4

What contextual factors have been identified as potential modifiers of effectiveness in studies of integrated interventions?

Key Question 5

What evidence gaps exist in the body of literature assessing the effectiveness of integrated interventions in terms of the following: populations, work settings, intervention types, outcomes, study designs, research methods, and contextual factors that may modify intervention effectiveness?

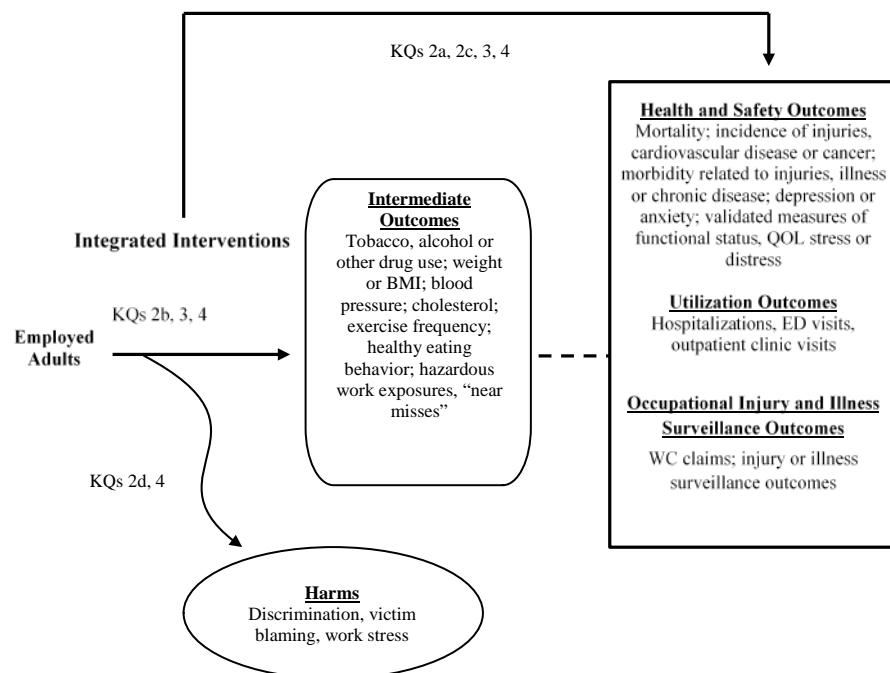
Key Question 6

What are the future research needs?

Analytic Framework

We developed an analytic framework to guide the systematic review process (Figure A). The analytic framework illustrates the population, interventions, outcomes, and adverse effects that guided the literature search and synthesis.

Figure A. Analytic framework for Total Worker Health™ interventions



BMI = body mass index; ED = emergency department; KQ = key question; QOL = quality of life; WC = workers' compensation

Methods

Topic Refinement and Protocol Review

The NIH P2P Working Group provided the initial KQs. The RTI-UNC EPC further refined them and incorporated guidance from a Technical Expert Panel (TEP) into the final research protocol. It was posted on the AHRQ website on May 26, 2015, at <http://www.effectivehealthcare.ahrq.gov/search-for-guides-reviews-and-reports/?pageaction=displayproduct&productid=2085>.

Literature Search Strategy

Search Strategy

We searched MEDLINE®, the Cochrane Library, the Cochrane Central Trials Registry, and PsycInfo from January 1, 1990, to March 26, 2015. An experienced research librarian used a

predefined list of search terms and medical subject headings (MeSH). A second (update) search will be completed during peer review.

We searched for unpublished studies relevant to this review using ClinicalTrials.gov and Academic Search Premier; on our behalf, the AHRQ Scientific Resource Center solicited scientific information packages (SIPs) via Federal Register notices or informational requests. We received a bibliography from NIOSH listing studies relevant to the TWH program. We used this bibliography to ensure that our database searches had not missed relevant citations. We searched reference lists of pertinent review articles for studies that we should consider for inclusion in this review.

Inclusion and Exclusion Criteria

We developed inclusion and exclusion criteria with the PICOTS framework (populations, interventions, comparators, outcomes, timeframes, and settings) in mind. We considered only trials or studies published in English.

The population of interest is employed adults. We excluded studies that enrolled only children or adolescents younger than 18 years of age.

Interventions of interest included any “integrated” intervention that met the definition of a TWH strategy (as defined earlier⁹). We included studies that evaluated a wide range of integrated approaches (e.g., organizational integration of OSH and HP, employee participation). To meet inclusion criteria, an intervention had to include a component to improve OSH (e.g., improving job stress or ergonomic hazards) and a component to improve HP (e.g., improving overall health, health behaviors, or risk factors for chronic diseases). We did not create inclusion or exclusion based on the degree or type of integration between OSH and HP.

Included studies for KQ 2 (effectiveness and harms of TWH interventions) had to have a concurrent control group. Acceptable comparisons included an OSH intervention only or an HP intervention only—i.e., any active comparator that was not integrated, no intervention, or usual practice. For descriptive purposes relating to KQs 1, 4, 5, and 6, we included studies assessing an eligible intervention in only one group (i.e., pre-post studies).

We specified a broad range of outcomes—intermediate and final health benefit outcomes and treatment harms (Figure A). We did not exclude studies based on the outcomes reported. For KQ 2, we limited our evidence synthesis to commonly reported outcomes that are considered to be important measures of worker health and safety. We determined which outcomes are common and considered important in this body of literature by reviewing prior studies of TWH interventions and asking for input from TEP members on our inclusion and exclusion criteria prior to finalizing the research protocol. Final health outcomes, for example, included quality of life, functional status, and occupational illnesses and injuries. Intermediate outcomes included rates of smoking cessation, healthy eating behavior, and outcomes related to hazardous workplace exposures or “near misses.” We also included health care utilization outcomes, rates of workers’ compensation claims and short-term disability claims. Finally, we searched for harms associated with TWH interventions, such as increased barriers to reporting work-related injuries or illnesses, work stress, discrimination, and victim-blaming.

We included studies conducted in any workplace setting in a developed country (“very high” human development index per the United Nations Development Programme).¹⁶

Study designs included randomized controlled trials (RCTs), and nonrandomized controlled trials, prospective cohort studies, and pre-post studies. We did not include prior reviews but

captured these in our database searches and used them to identify studies that our searches may have missed.

Study Selection

Trained members of the research team reviewed article abstracts and full-text articles. Two members independently reviewed each title and abstract using the predefined inclusion and exclusion criteria. Studies marked for possible inclusion by either reviewer underwent a full-text review. Two members of the team independently reviewed each full-text article. If both reviewers agreed that a study did not meet the eligibility criteria, we excluded it; each reviewer recorded the primary reason for exclusion. If reviewers disagreed, they resolved conflicts by discussion and consensus or by consulting a third member of the review team.

We screened unpublished studies and reviewed SIPs using the same title/abstract and full-text review processes. The project coordinator tracked abstract and full-text reviews in an EndNote database (EndNote® X4).

Data Abstraction

We developed a template for evidence tables using the PICOTS framework and abstracted relevant information into them using Microsoft Excel. We recorded characteristics of study populations, interventions, comparators, settings, study designs, methods, and results. Six trained members of the team participated in the data abstraction. One reviewer initially abstracted the relevant data from each included article; a second member of the team reviewed each data abstraction against the original article for completeness and accuracy.

Risk-of-Bias Assessment

To assess the risk of bias (internal validity) of studies eligible for KQ 2, we used predefined criteria based on the AHRQ *Methods Guide*. These criteria included questions to assess selection bias, confounding, performance bias, detection bias, and attrition bias (i.e., those about adequacy of randomization, allocation concealment, similarity of groups at baseline, masking, attrition, use of ITT analysis, method of handling dropouts and missing data, reliability and validity of outcome measures, and treatment fidelity).¹⁷ Appendix C of the main report lists the specific questions used for evaluating the risk of bias of all included studies. It also includes a table showing the responses to these questions and risk-of-bias ratings for each study and explains the rationale for all ratings that were either high or medium.

In general terms, results from a low risk-of-bias study are considered to be valid. A study with moderate risk of bias is susceptible to some risk of bias but probably not enough to invalidate its results. A study assessed as high risk of bias has significant risk of bias (e.g., stemming from serious errors in design, conduct, or analysis) that may invalidate its results. To assess publication bias, we looked for evidence of unpublished literature through searches of gray literature (clinicaltrials.gov). We also reviewed (when available) the original protocols for included trials to assess for selective outcome reporting.

We determined the risk-of-bias ratings using the responses to all questions assessing the various types of bias listed above. To receive a low risk of bias rating, we required favorable responses to most questions, and any unfavorable responses had to be relatively minor. We gave high risk-of-bias ratings to studies that we determined to have a major methodological shortcoming in one or more categories based on our qualitative assessment. Common

methodological shortcomings contributing to high ratings were high rates of attrition or differential attrition and inadequate methods used to handle missing data.

Two independent reviewers assessed the risk of bias for each study. Disagreements between reviewers were resolved by discussion and consensus or by consulting a third member of the team.

Data Synthesis

Quantitative synthesis (meta-analyses) was not appropriate to this topic given the heterogeneity in the included populations, interventions, comparators, outcomes, work settings and geographic settings of included studies. We did all analyses qualitatively, based on our reasoned judgment of similarities in interventions, measurement of outcomes, and homogeneity of occupational groups.

Strength of the Body of Evidence

We graded the strength of evidence based on the *EPC Methods Guide*.¹⁸ The EPC approach incorporates five key domains: study limitations, directness, consistency, precision of the evidence, and reporting bias.

Grades reflect the strength of the body of evidence to answer each KQ. A grade of high strength of evidence indicates that we have high confidence that the evidence reflects the true effect. Moderate strength of evidence indicates that we have moderate confidence that the evidence reflect the true effect. Low strength of evidence suggests that we have low confidence that the evidence reflects the true effect. Insufficient evidence signifies that the evidence is not available, that we are unable to estimate an effect, or that we have no confidence in the estimate of the effect. We graded the strength of evidence for an outcome only when it was reported in at least one study rated medium risk of bias; studies rated high risk of bias were used to assess the consistency of evidence when they reported the same outcomes in similar populations of workers.

Two reviewers assessed each domain independently and also assigned an overall grade for comparisons for each key outcome; they resolved any conflicts through consensus discussion. If they did not reach consensus, the team brought in a third party to settle the conflict.

Applicability

We assessed the applicability both of individual studies and of the body of evidence. For individual studies, we examined factors that may limit applicability (e.g., characteristics of populations, interventions, comparators, work settings, and geographic settings). Such factors may lessen our ability to generalize the effectiveness of an intervention to use in other occupational groups or work settings. We abstracted key characteristics of applicability into evidence tables. During data synthesis, we assessed the applicability of the body of evidence using the abstracted characteristics.

Peer Review and Public Commentary

Experts in workplace health promotion and occupational safety and health (clinicians and researchers) and experts in evidence-based assessments of workplace and community interventions were invited to provide external peer review of the draft report. AHRQ and an Associate Editor, who are leaders in their respective fields, also provided comments. The draft

will be posted on the AHRQ website for 4 weeks to elicit public comment. We will respond to all reviewer comments and note any resulting revisions to the text in the “Disposition of Comments Report.” This disposition report will be made available 3 months after AHRQ posts the final review on its website.

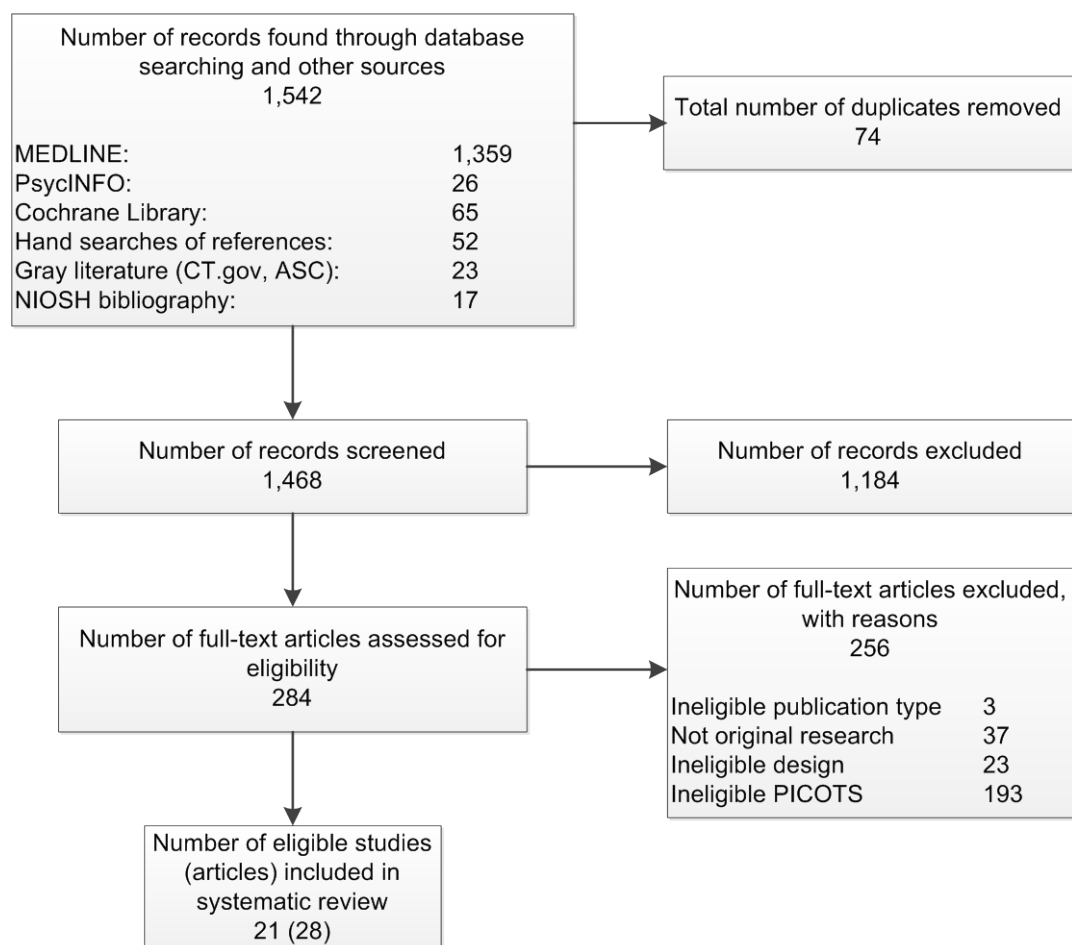
Results

We report results by KQ; details results are available in the full report and are summarized below. For KQ 1 (characteristics of TWH interventions), we describe the characteristics of all included studies using a PICOTS framework. For KQ 2 (treatment effectiveness and harms), we grouped by outcome category. Tables A (in discussion below) summarize key findings and strength of evidence grades for KQ 2. The full report contains summary tables (for results, reported in Chapters 3, 4, and 5). In the main report, Appendix C documents risk-of-bias assessments and Appendix D presents strength of evidence grades. Evidence tables (showing all abstracted data by study) will be uploaded to AHRQ’s Systematic Review Data Repository (SRDR) for reference and use in future research.¹⁹

Literature Searches

Figure B (disposition of articles diagram) depicts our literature search results. Searches of all sources identified a total of 1,468 potentially relevant citations. We included 21 studies described in 28 publications.^{10-12,20-44} Of the 21 included studies, 12 studies had a concurrent control group and were also eligible for KQ 2. Appendix B provides a complete list of articles excluded at the full-text screening stage, with reasons for exclusion.

Figure B. Disposition of articles for Total Worker Health™ interventions



ASC = Academic Search Complete; CT.gov = ClinicalTrials.gov; NIOSH = National Institute of Occupational Safety and Health; PICOTS = populations, interventions, comparators, outcomes, timeframes, settings.

Key Question 1. Characteristics of Studies Evaluating Total Worker Health™ Interventions

Work Setting and Populations

Across all 21 studies, we encountered substantial heterogeneity with respect to the work settings, populations, interventions, and the outcomes evaluated. Studies enrolled populations employed primarily in manufacturing, construction, or health care work settings. Workers from the manufacturing industry were more commonly male; workers from the health care and social assistance industry were overwhelmingly female. Commonly targeted workers were between 30 and 50 years of age; only one study evaluated a younger workforce (mean <30 years of age) and only one study evaluated an older workforce (mean >50 years of age). Few studies described the baseline health status or medical comorbidity of included populations. Investigators generally did not describe either the OSH or the HP services available at worksites (in addition to the intervention under study).

Interventions and Comparators

All studies assessed an intervention focused on an integrated objective (in terms of addressing both OSH and HP). Eight interventions involved strategic integration across organizational departments responsible for OSH and HP, and fifteen involved worker participation in the development, design, planning, and/or implementation of the intervention. Five studies assessed an intervention with both strategic integration and worker participation. Most studies were multicomponent interventions; only four evaluated a single component intervention. Only one included study assessed the effectiveness of integration alone (without added OSH or HP content). Eleven studies assessed interventions that included new, comprehensive HP and OSH components not previously available to workers; six included mostly HP content (tailored to the specific needs of workers) and three studies assessed interventions that focused primarily on addressing OSH but also included components aimed at HP. Of the 21 studies, 12 included concurrent control groups, most of which received no intervention. Four studies included active control groups that received a HP component

Outcomes

Overall, these 21 studies assessed a diverse set of outcomes. Few studies measured the same outcomes in similar populations of workers. Approximately half of studies evaluated at least one final health outcome (e.g., quality of life, functional status), subjective health complaints, or stress. Few studies evaluated work-related injuries or illnesses; job stress was the most commonly outcome related to OSH. Commonly reported intermediate health outcomes were body mass index (BMI), biomarkers associated with risk of cardiovascular disease (e.g., cholesterol), and health behaviors (primarily physical activity, smoking, and dietary behaviors). Few studies evaluated work-related injuries or illnesses. Several studies assessed outcomes that we did not include for KQ 2 (i.e., on effectiveness and harms of TWH integrations); the two addressed most often were absenteeism and economic evaluations.

Key Question 2. Effectiveness and Harms of Interventions

Evidence for the effectiveness and harms of TWH interventions for improving outcomes consisted of nine RCTs, two nonrandomized controlled trials (NRCTs), and one prospective cohort study.^{10,20,23,24,26-28,33,34,37,38,44} Few studies of TWH interventions assessed the same outcomes among similar populations of workers. We rated two RCTs as medium risk of bias^{27,28} and the other 10 studies as high risk of bias (mainly because of a high risk of selection bias). Most studies had high overall attrition (ranging from 14 percent to 45 percent); many studies had differential attrition across study arms. In general, studies rated high risk of bias did not use any statistical methods to address missing data. Other common areas of bias included baseline differences between groups that the investigators did not address in their analyses.

The 12 KQ 2 studies were quite different; few studies of TWH interventions assessed the same outcomes among similar populations of workers. We found no evidence from studies rated low or medium risk of bias for many important health and safety outcomes of interest. Table A summarizes our key findings by outcomes. Some evidence (low SOE) supported the effectiveness of TWH interventions for improving rates of smoking cessation over 22 to 26 weeks and increasing the consumption of fruit and vegetable intake over 26 to 104 weeks compared with no intervention. Evidence was insufficient for assessing the effectiveness of integrated interventions for improving levels of physical activity or decreasing the intake of red meat.

Table A. Summary of key findings and strength of evidence for Total Worker Health™ interventions

Population, Intervention and Comparator Time-point	N Studies; N Subjects Study Limitations	Outcome and Results	Strength of Evidence
Construction laborers ²⁷ and manufacturing workers ¹⁰ Integrated Intervention versus no intervention; 22-26 weeks	2; 737 Medium or High	<p>One RCT rated medium ROB:²⁷ % of baseline smokers reporting 7-day abstinence (smoking) at 26 weeks: G1: 19% G2: 8% p=0.03</p> <p>% of baseline tobacco users reporting 7-day abstinence (any tobacco use) at 26 weeks: G1: 19% G2 7% p=0.005</p> <p>One RCT rated high ROB:¹⁰ % of baseline smokers reporting 7-day abstinence at 22 weeks: G1: 26% G2: 17% p=0.014</p>	Low for benefit
Manufacturing workers ^{20,28} and construction workers ²⁷ Integrated Intervention versus no intervention; 26-104 weeks	3; 6056 Medium or High	<p>Two RCTs rated medium ROB: Servings per day, mean change from baseline:²⁷ G1: +1.52 (SD=3.89) G2: -0.09 (SD=3.31) p= <0.0001</p> <p>% of participants consuming 5 or more servings of fruits and vegetables per day, mean change from baseline:²⁸</p> <p>Overall: G1: +5.4% G2: +1.7% p=0.41</p> <p>Managers: G1: -5.5% G2: +3.6% p=0.048</p> <p>Workers: G1: +7.5% G2: +1.1% p=0.048</p> <p>One RCT rated high ROB:³⁴ Servings per day, mean change from baseline: Servings per day, mean change from baseline: G1: 0.22 G2: 0.09 p=0.04</p>	Low for benefit

Table A. Summary of key findings and strength of evidence for Total Worker Health™ interventions (continued)

Population, Intervention and Comparator Time-point	N Studies; N Subjects Study Limitations	Outcome and Results	Strength of Evidence
Manufacturing workers; ²⁸ Integrated Intervention versus no intervention; 78 weeks	1; 3092 Medium	% of participants consuming 3 or fewer servings of red meat per week, mean change from baseline: G1: +4.1% G2: + 3.0% P=0.72	Insufficient
Manufacturing workers; ²⁸ Integrated Intervention versus no intervention; 78 weeks	1; 3092 Medium	Change from baseline in the percentage of participants who exercise ≥ 2.5 hours per week: Overall: G1: +5.4 G2: -0.9% p=0.23 Managers: G1: -2.0 G2: +3.7 p= 0.09 Workers: G1: +7.1 G2: -2.1 p= 0.09	Insufficient

N= number; RCT= randomized controlled trial; ROB: risk of bias; SD = standard deviation.

Key Question 3. Components of Effective Interventions

We evaluated common characteristics of interventions that were effective for improving any outcome eligible for KQ 2 for which the SOE for benefit was at least low. Overall, we were not able to make very few SOE conclusions due to limitations of the evidence base and heterogeneity across studies; four studies, primarily enrolling blue-collar manufacturing and construction workers, contributed to our SOE grades for smoking cessation and healthy eating outcomes. We focused on characteristics of interventions that relate to the approach to integration and specific content of the intervention.

Effective interventions were informed by worker participation—in the development, design, planning, or implementation of the intervention (or in more than one of these steps). All effective interventions included comprehensive program content that highlighted the potential additive or synergistic risks of hazardous workplace exposures and health behavior. Effective interventions tailored intervention components or materials to cultural or social aspects of the worker population (e.g., to workers with low literacy skills, workers for whom English is not their first language). All effective interventions are multicomponent, complex interventions that reinforce messages about behavior change through multiple modes of delivery over time.

Key Question 4. Contextual Factors

We abstracted data from included studies that related to contextual factors that the investigators had identified as potential modifiers of intervention effectiveness. Such factors had been noted in their results (e.g., whether the intervention was more or less effective at worksites that differed by a specific contextual factor) or in discussion sections as ones that could have

potentially influenced the effectiveness of interventions. Seven studies identified one or more such contextual factors. Work organization factors and union membership status were the two most commonly mentioned contextual factors. In general, work organization factors (e.g., work schedules or changes in overtime policies) were described as factors that likely reduced worker participation and limited intervention effectiveness, while union membership was described as a factor that may have positively influenced intervention effectiveness (by promoting worker participation or facilitating the implementation of the intervention). Other variables noted by at least one study included the following: presence of another (concurrent) OSH or HP policy implemented during the study period, health insurance status or access to primary care services, and employee stress or strain related to company downsizing during the intervention period.

Key Question 5. Research Gaps

We found numerous gaps in the literature base supporting TWH interventions in terms of work settings and populations, interventions, comparators, and deficiencies in methods.

Work Settings and Populations

No study enrolled workers from states in the Southwest; only one study each was conducted in a Southeastern or Western state (Arkansas and Oregon, respectively). Only one US study enrolled a population across different US regions.²⁷

No studies enrolled workers from industries in these sectors: wholesale and retail trade; utilities (electricity, water, gas); information (publishing, broadcasting, telecommunications); finance and insurance; real estate; professional, scientific and technical services; educational services; arts, entertainment, and recreation; or accommodation and food services. The service sector as a whole (e.g., retail, transportation, communications, health care) is underrepresented in included studies when considering the prevalence of work-related injuries among workers employed in this sector.

In terms of specific occupational groups, only three studies enrolled office and administrative support workers (the occupational group with the largest employment in the United States).⁴⁵ The following occupations were not represented in included studies: sales and related occupations (the second-largest major occupational group in the United States);⁴⁵ food preparation and serving workers (the third-largest major occupational group in the United States).⁴⁵ Finally, workers in education and training represent a large group that was not represented in the studies we reviewed.

No study enrolled populations of workers who were very young or very old. Women were underrepresented in industries other than those typically conducted in a health care setting. No study addressed differences in outcomes among subgroups of workers defined by age, sex, race, ethnicity, comorbidity, or income. People who work part-time (regardless of their occupation) were often excluded from studies.

Interventions

Studies evaluated quite diverse interventions; the type and level of integration involved in interventions varied substantially. We found no direct evidence on whether certain strategies of integration are more or less effective than others. A minority of included studies (eight studies) evaluated an intervention that included organizational integration (e.g., multiple departments within the work setting were involved with planning, implementing, and managing the intervention).

We found no studies that directly assessed whether specific combinations (or specific types) of program content were more or less effective than other combinations. Studies differed in terms of the degree to which program content focused on OSH concerns versus HP concerns.

We could not assess whether strategies were more or less effective based on their complexity (single versus multiple components) or level of influence (e.g., environmental or administrative controls, individual worker education, or both). Most studies assessed complex, heterogeneous interventions that targeted both the worker and the worksite. Few studies assessed single-component interventions aimed at improving the work environment or work structure with the associated goals of improving OSH and promoting personal health.

Comparators

In general, studies were not designed to assess directly the effectiveness of integration alone (compared with no integration). Most studies compared an intervention that addressed both OSH and HP with no intervention. The effects of the new HP or OSH component (or both) offered to the intervention group could not be separated from the effects of integration. Studies that compared an intervention with no intervention (or usual workplace programs) generally did not describe the OSH or HP programs already in place and available to workers.

Outcomes

Although we considered a wide range of outcomes for this review, we were able to rate the evidence for only two: smoking cessation and changes in fruit and vegetable consumption. Very few studies measured outcomes important to OSH. Whether integrated interventions improve workplace safety (compared with OSH programs or policies that are not integrated with HP) is unclear.

No study eligible for KQ reported on the following outcomes: incidence of injuries, cardiovascular disease, or cancer; morbidity related to injuries, illnesses, or chronic disease (including work-related injuries and illnesses); depression or anxiety; BMI; or use of health care. A few studies (all high risk of bias) reported on the following: validated measures of quality of life or functional status; stress (job or general stress); rates of workers' compensation claims, short-term disability claims, alcohol use, and illicit drug use.

None of these studies prespecified harms as an outcome of interest. We found no information pertaining to increased barriers to reporting work-related injuries or illnesses, work stress, adverse effects on personal health, discrimination, or victim-blaming.

Deficiencies in Methods

As already noted, 9 studies used a pre-post design; because of the inherent risk of bias in pre-post studies, we did not include them in addressing benefits and harms of TWH interventions. The 12 studies eligible for KQ 2, still had had numerous methodological limitations. The RCTs often did not report had randomization and allocation concealment adequately. Most RCTs randomized worksites (not workers), but the numbers of worksites randomized were sometimes small. Investigators often did not adequately describe the flow of participants (especially for studies randomized or assigned interventions at the worksite level).

Most studies mounted surveys before and after an intervention, but response rates to baseline surveys among eligible workers were sometimes low (or not reported). This factor contributed to selection bias.

Overall attrition was high in several studies (14 percent to 54 percent in studies rated high risk of bias). Most studies performed a complete-case analysis; participants (or worksites) with missing data were excluded from the analysis. We encountered baseline differences between groups in several studies; statistical analyses often did not address these differences. Several studies had small sample sizes and thus lacked power for determining intended effects.

Investigators sometimes did not provide information on their statistical methods; also, authors sometimes did not provide measures of variance (e.g., confidence intervals) for outcomes. In several studies, contamination of the control arms compromised internal validity; for example, another worksite policy or program initiated during the intervention period could have influenced outcomes measured in the study.

Finally, in some cases, the length of followup may not have been adequate to assess the stability of findings over time. Only six studies measured outcomes at or beyond 1 year.

Key Question 6. Future Research Needs

Work Settings and Populations

Including a broader range of workers in future studies could increase the applicability of TWH interventions. Future research could target specific worksites in diverse regions of the United States that differ in terms of state government policy on economic development and labor; these factors can influence where employers locate and the attention they give to worker safety.

The applicability of interventions that were effective for reducing smoking and improving fruit and vegetable consumption is limited. Future studies should consider similar interventions in other groups of workers (e.g., other blue-collar workers) or different types of manufacturing sites to help clarify (1) the strength of evidence for these interventions and (2) the applicability across various work settings and populations.

Consideration should be given to a broader set of populations of workers in the service sector, such as retail, transportation, communications industries, and health care, in future TWH interventions. These populations have a high burden of occupational injuries. Occupational groups representing the largest number of US workers should also be a focus of future research; these include (but might not be limited to) office and administrative support workers, sales and related occupations, and food preparation and serving workers. Future studies could enroll workers from diverse work settings (who receive a similar intervention, for example) to assess which factors related to the work setting modify the benefits (and potential harms) of TWH interventions. This approach might include recruiting worksites that differ by size, ownership of the enterprise (e.g., whether private or public sector), work organization (e.g., full- versus part-time job patterns), and unionization.

Future studies could assess whether outcomes differ among subgroups of workers defined by occupation, age, sex, race, ethnicity, comorbidity, or income (when appropriate). Whether certain categories of workers would benefit more from TWH compared with others is not clear. Future studies could enroll populations who are likely to have specific concerns related to work-life balance (e.g., caregivers of young children or elderly parents, single parents) or workers with unique health and safety concerns (older workers or those who are very young).

Interventions

Future studies should clearly describe the approach used to integrate OSH and HP programs, policies, or goals. Investigators should lay out a framework for how the integrated intervention addressed *both* OSH and HP goals. Studies should focus on interventions targeted at work environment or work structure. Work schedules (e.g., shift work, work hours), for example, have been highlighted as an issue relevant to TWH. Few studies have assessed whether specific integrated strategies that modify the work environment (coordinated across OSH and HP departments, for example) improve worker health more than those focusing primarily on providing education or behavioral counseling to individual workers.

Comparators

An established body of literature supports the efficacy of worksite wellness interventions on smoking and other important outcomes.⁴⁶ Future studies should try to assess directly the effectiveness of integration itself; in other words, this aspect of TWH interventions should be isolated from the effects of a new or improved OSH or HP component. Studies should directly compare an integrated approach with a program that has similar OSH and HP elements available but does not deliberately coordinate them. In addition, investigators should clearly describe what OSH and HP programs are already in place and available to workers outside the intervention being evaluated.

Outcomes

Future studies should consider the feasibility of measuring OSH outcomes. To understand whether “integration” improves both OSH and HP, researchers need to examine indicators of improved safety.

Future studies should also consider direct measures of worker health if possible. For example, investigators should try to use validated measures of health status, functional status, and wellness. Researchers should measure the incidence or morbidity associated with chronic diseases when feasible, particularly in populations of workers at higher risk of chronic conditions (e.g., older workers).

Research teams should also choose intermediate outcomes carefully. These outcomes should be based on strong evidence for linkages to final health outcomes and for relevance to a particular population of workers.

Finally, future studies should consider assessing harms or potential unintended consequences of the interventions. Measures of harms and unanticipated effects should be made at both the individual worker and the organizational level.

Deficiencies in Methods

Worksite randomized trials should follow the recommendations for reporting outlined in the Consolidated Standards of Reporting Trials (CONSORT) statement extension to cluster randomized trials⁴⁷ or the Ottawa Statement on the ethical design and conduct of cluster randomized trials.⁴⁸ In particular, authors should provide a clear diagram to show the flow of participants from group assignments through the final analysis. Of the 21 studies we included in this review, 9 had a pre-post design; because of the inherent risk of bias in pre-post studies, we did not include them in our assessment of the benefits and harms of TWH interventions. Among

the 12 studies eligible for KQ 2 (i.e., those with a concurrent control group), many had methodological limitations

Randomized trials are not always feasible because of barriers associated with studying populations of workers. Well-designed prospective cohort studies (or nonrandomized trials) with a concurrent control group could inform the strength of evidence related to TWH interventions. Studies without a control group are unlikely to contribute significantly to an understanding of the strength of evidence supporting TWH interventions (because of the inherent bias in the design); these designs should be avoided.

Investigators should plan for high attrition (and differential attrition between intervention and control groups). In addition, they should use methods to address missing data (e.g., imputation of missing data) when attrition is high; these methods should be informed by the potential reasons for missing data and whether the outcomes of participants is likely to change after they drop out.

Studies should address baseline differences between groups (when they are present) using appropriate statistical methods. Furthermore, investigators should report measures of variance (e.g., confidence intervals) for all outcomes they evaluate. Finally, in reporting their studies, authors should highlight whether other (concurrent) OSH and HP policies or programs had been in place or implemented during the intervention in question; this will enable them to assess bias associated with contamination.

Discussion

Key Findings and Strength of Evidence

We limit our discussion to key findings from the 21 included studies for all KQs. Other results can be found in the results section above and in more detail in the main report.

Key Question 1. Characteristics of Studies Evaluating Total Worker Health™ Interventions

Work settings, populations, interventions, and the outcomes all differed considerably across this evidence base. Studies enrolled populations employed primarily in manufacturing, construction, or health care settings. Overall, targeted workers were mainly between 30 and 50 years of age. All studies assessed an intervention focused on an integrated objective to address both OSH and HP; eight interventions included strategic organizational integration across departments, fifteen included worker participation (in the development, design, planning, and/or implementation of the intervention), and five included both strategic coordination and workers participation. Most studies were multicomponent and included new, comprehensive HP and OSH components not previously available to workers. The outcomes assessed were highly varied and usually not measured in similar populations of workers.

Key Question 2. Effectiveness and Harms Associated of Interventions

Evidence for the effectiveness and harms of TWH interventions for improving outcomes consisted of nine RCTs, two nonrandomized controlled trials, and one prospective cohort study.^{10,20,23,24,26-28,33,34,37,38,44} Of these, two RCTs were medium risk of bias^{27,28} and the others high risk of bias. Studies rated medium risk of bias (rather than high) provided little or no evidence for many important health and safety outcomes of interest. Some evidence (low SOE) supported the effectiveness of TWH interventions for improving rates of smoking cessation over 22 to 24 weeks and increasing the consumption of fruit and vegetable intake over 26 to 104

weeks compared with no intervention. We had no useful information about integrated interventions to increase physical activity or decrease the intake of red meat.

Key Question 3. Components of Effective Interventions

We evaluated common characteristics of interventions that were effective for improving any outcome eligible for KQ 2 for which the SOE for benefit was at least low. We were able to make very few SOE conclusions due to limitations of the evidence base and heterogeneity across studies; four studies, primarily enrolling blue-collar manufacturing and construction workers, contributed to our SOE grades for smoking cessation and healthy eating outcomes. Effective interventions were informed by worker participation—in the development, design, planning, or implementation of the intervention (or in more than one of these steps). All effective interventions included comprehensive program content that highlighted the potential additive or synergistic risks of hazardous workplace exposures and health behavior. Effective interventions tailored intervention components or materials to cultural or social aspects of the worker population.

Key Question 4. Contextual Factors

We abstracted data from included studies that related to contextual factors identified by authors as potential modifiers of intervention effectiveness in all included studies. Of the 21 studies reviewed, seven identified a contextual factor that could have influenced the effectiveness of interventions—these were mainly work organization factors and union membership status. Three other factors (from at least one study) included the following: presence of another (concurrent) OSH or HP policy implemented during the study period, health insurance status or access to primary care services, and employee stress or strain related to company downsizing during the intervention period.

Key Question 5. Research Gaps

As noted above in results, this knowledge base has numerous gaps. Of particular note is the lack of representation across regions of the United States and the appreciable underrepresentation of the service sector (taking into account the prevalence of work-related injuries among workers employed in this sector). Women were underrepresented (except for those employed in health care settings) few studies evaluated interventions in populations that varied by race, ethnicity, comorbidity, and other factors. Among the important gaps are whether certain strategies of integration are more or less effective than others and whether specific combinations or types of program content were more or less effective than others. Most studies compared an intervention with both OSH and HP components with no intervention; the effects of the new OSH or HP elements could not be separated from those presumably attributable to integration. Very few or no studies examined OSH outcomes, harms or unintended consequences, or any of the following: incidence of injuries or chronic diseases, morbidity associated with chronic diseases, and measures of use of health services. Many studies had methodological limitations that include differences between intervention and comparison groups at baseline; small sample sizes and power; high overall or differential attrition; and choices of statistical analyses (e.g., no methods to address missing data).

Key Question 6. Future Research Needs

We enumerated above numerous areas for future research (to fill gaps) and for improvements in study designs and methods. Addressing such issues could increase the applicability of information about TWH interventions. These include studying a broader range of workers and worksites in more regions and diverse states of the country (to account for different policies about economic development, labor issues, and worker safety). Moreover, examining similar interventions in other or different groups of workers or work settings might help clarify not only the SOE for interventions but also how generalizable they are across various work settings and populations. Funders should give more consideration workers in the service sector industries, and health care or other parts of the economy with high levels of occupational injuries. Finally, subgroups of workers defined by occupation, age, sex, race, ethnicity, comorbidity, or income (when appropriate) deserve more attention overall and in terms of whether certain categories would benefit more (or less) from TWH interventions. We emphasized the need for later research to examine directly the effectiveness of integration itself (in isolation from the effects of any new or improved OSH or HP component) and to describe clearly what OSH and HP programs might already be in place. In terms of outcomes, future studies should do a better job of measuring OSH outcomes, so as to clarify whether “integration” improves both OSH and HP. We noted the need for direct measures of final health outcomes and good selection of intermediate outcomes that links them solidly to final health outcomes, taking the worker population specifically into account. Finally, we advise that future research give more attention to possible negative side effects or unintended consequences of interventions for both organizations and individual workers.

Given that TWH trials may randomize at the worksite level, we call attention to the need to reflect CONSORT principles (for reporting) and those relating to cluster randomized trials (for design and informed consent issues). More well-designed prospective cohort studies or nonrandomized trials with concurrent control groups are needed could inform the strength of evidence related to TWH intervention because studies without a control group are unlikely to yield meaningful information about the effectiveness (or lack of it) of TWH interventions. Finally, we urge investigators to plan ahead for how to handle differences between worker groups at baseline and high attrition (and differential attrition) and use methods to address missing data when necessary, such as imputation of missing data or baseline observation carried forward approach if appropriate. Studies should address baseline differences between groups (when they are present) using appropriate statistically methods and report measures of variance (e.g., confidence intervals) for outcome measures.

Findings in Relation to What Is Already Known

This emerging body of literature did not yield any previous systematic review that was similar in scope to ours or that assessed the SOE related to common outcomes of TWH interventions. One prior systematic review¹⁴ and one expert (or narrative) review¹³ gave broad overviews of TWH interventions. Our results are, in general, consistent with those in earlier reviews with respect to limitations of the evidence base. For example, although Anger and colleagues noted that integrated interventions improved risk factors for chronic diseases, they concluded that little or no evidence shows that integration itself confers a significant benefit and that this may be “perhaps the most glaring gap in the TWH literature.”¹⁴ Like previous reviews, we took a broad approach to defining “integration.” Not surprisingly, our review and the two earlier reviews differ slightly in terms of included studies and whether we considered them

integrated or not. For example, one study assessing a worksite wellness program designed for firefighters was in the review by Anger and colleagues; we excluded it, however, because it had no explicit coordination between OSH and HP programs and no obvious OSH content.⁴⁹ Our systematic review methods differ from those of earlier reviews. Prior reviews either did not address potential bias associated with TWH interventions or used study design labels as a proxy for risk of bias of included studies.¹⁴ We used standard techniques for assessing risk of bias for individual trials or observational studies (documented in Appendix C of the main report) and grading the SOE for entire bodies of evidence (Appendix D).

Regarding overall conclusions about the effectiveness of TWH interventions, we assessed the SOE for specific outcomes whereas prior reviews offered only general statements about the positive effects of TWH interventions or summarized benefits using primarily numbers of statistically significant outcomes across studies; they generally did not consider study limitations, directness, consistency, or precision in evaluating their findings.^{13,14} In general, then, the two prior reviews draw stronger conclusions about the benefits of integrated integration than we reached.

Implications for Employer and Policy Decisionmaking

The P2P goals include hosting workshops to identify research gaps in a selected scientific area (including methodological and scientific weaknesses), suggest research needs, and advance this through unbiased, evidence-based assessments of a complex public health issue.¹⁵ To this end, we have described the body of evidence supporting TWH interventions, laid out scientific and methodological weaknesses, and proposed areas and methods for future research. Although this evidence base is limited, we found evidence (low SOE) supporting integrated interventions in improving rates of smoking cessation over 22 to 26 weeks and consumption of fruit and vegetables over 26 to 104 weeks. These effective interventions shared the following special characteristics of interest to employers and policymakers:

1. Worker participation informed the development, design, planning, or implementation of the intervention.
2. Their comprehensive program content highlighted possible additive or synergistic risks of hazardous workplace exposures and health behavior.
3. Interventions tailored intervention components or materials to various cultural or social aspects of the worker population (e.g., to workers with low literacy skills or those for whom English was not a first language).

Applicability

During our review process, we systematically abstracted key factors (identified a priori) that may affect the applicability of the evidence base—i.e., “the extent to which the effects observed in published studies are likely to reflect the expected results when a specific intervention is applied to the population of interest under real-world conditions.”⁵⁰ We focused on issues for populations of workers and worksites in the United States. Studies demonstrating the effectiveness of TWH interventions for improving rates of smoking cessation or increasing the consumption of fruit and vegetable consumption involved US blue-collar workers and used survey data collected before 2004 (and from the same group of researchers^{20,27,28,34}). Since the mid-2000s, workplace HP and OSH programs have very likely improved; whether the results of these trials would be applicable to worksites that already have active HP programs or policies that promote smoking cessation and healthy eating is not clear.

More recent changes in health policy or practice (such as community health interventions and health care) may limit the applicability of studies published 10 or more years ago. After implementation of the Affordable Care Act, national surveys show improvements in self-reported health-care coverage, access to primary care and medications, greater affordability, and better health among younger populations of men (at least in states that expanded Medicaid coverage).⁵¹ Access to smoking cessation services may be more widely available because of these changes; intervention components evaluated in older studies could now be considered “usual care” in some settings.

Limitations of the Review Process

As documented earlier, our inclusion criteria for interventions were broadly defined, and studies meeting those criteria used a range of strategies to address both OSH and (especially) HP concerns. We based our work on NIOSH definitions for TWH programs and related guidance.⁹ Nevertheless, relevant studies were often published before the terms “integrated intervention” or “total worker health” came into use. Thus, because of a lack of consistent terminology related to “integration” and (potentially) inadequate reporting or description of intervention components in some studies, we may have missed some work that might have involved integrated interventions.

We did our searches to identify studies that would generally be considered to involve integrated TWH intervention; however, such studies are not indexed by standard or consistent terms. To address this deficiency, we solicited and received a database from NIOSH that listed studies deemed relevant to TWH. Our search strategies had identified the vast majority of these studies. Nevertheless, some studies that we excluded might still be considered related to TWH.

Publication bias and selective reporting of outcomes are potential limitations. Although we searched for unpublished trials and unpublished outcomes, we did not find direct evidence of either of these biases. Many of the included trials were published before trial registries (e.g., clinicaltrials.gov) became available; had we been able to consult such registries, we would have had greater certainty about the potential for either type of bias.

Finally, for this review, we excluded non-English-language studies based largely on limitations of time and resources. However, we identified non-English language studies in our searches and did not see any references that were otherwise likely to meet our inclusion criteria. Searches of the NIOSH references also did not uncover any non-English studies. Given this, and the fact that TWH is a relatively new strategy, we believe that limiting our review to English-language studies had little effect.

Limitations of the Evidence Base

As described above the limited scope and volume of this evidence base meant that it was inadequate to draw conclusions for some questions or subquestions of interest, even though we did go beyond trial data to include observational studies.

For KQ 2, we limited our synthesis to studies with a concurrent control group, but limiting by study design is unlikely to have had a major effect on our SOE grades assessments for effectiveness or harms issues. For KQ 5 and 6, however, we did include pre-post studies, but these questions did not entail making SOE judgments. Furthermore, among studies eligible for KQ 2, many had methodological drawbacks that introduced significant overall study limitations (especially nonresponse to surveys, high overall or differential attrition). Of particular importance for future research is to deal with the following problems: reporting of randomization and allocation concealment; differences in intervention and control groups at baseline; small

sample sizes (and thus lack of power for determining intended effects); lack of clarity in defining intervention components; and adequate description or documentation of statistical tests and results.

Conclusions

Overall, we found the body of evidence to be small, heterogeneous in terms of work settings and populations, interventions, and outcomes; in some areas of interest, information was nonexistent. The small size of the body of evidence is not altogether surprising given that the concept of “integration” is relatively new. The body of evidence may reasonably be expected to grow over the next few years. Evidence of low SOE supported the effectiveness of TWH interventions for improving rates of smoking cessation over 22 to 26 weeks and increasing the consumption of fruit and vegetable intake over 26 to 104 weeks compared with no intervention. Evidence was insufficient to assess the effectiveness of integrated interventions for improving levels of physical activity or decreasing the intake of red meat. Effective interventions were informed by worker participation and included comprehensive program content that highlighted the potential additive or synergistic risks of hazardous workplace exposures and health behavior. The applicability of these findings is limited; most trials enrolled blue-collar workers (from manufacturing worksites in Massachusetts or unionized construction workers) before 2004.

Additional, adequately powered, multi-site RCTs or other prospective studies with a concurrent control are needed to replicate encouraging findings from only a few trials. Investigators should design studies explicitly to assess the benefits of integration alone (separate from new HP or OSH components). Including a broader range of workers in future studies could increase the possible applicability of TWH interventions and enable reviewers to assess the consistency of findings. It might also answer the question of whether integrated strategies are more effective (or not) in groups of workers who differ by demographic, social, or occupational characteristics that contribute to the risk of adverse health outcomes.

References

1. Leigh JP, Markowitz SB, Fahs M, et al. Occupational injury and illness in the United States. Estimates of costs, morbidity, and mortality. *Arch Intern Med.* 1997 Jul 28;157(14):1557-68. PMID: 9236557.
2. Dembe AE. The social consequences of occupational injuries and illnesses. *Am J Ind Med.* 2001 Oct;40(4):403-17. PMID: 11598991.
3. Bureau of Labor and Statistics. Employer-Reported Workplace Injury and Illness Summary. Washington, DC: Bureau of Labor Statistics, U.S. Department of Labor; 2013 4 December, 2014. www.bls.gov/news.release/osh.nr0.htm. Accessed 16 December, 2014.
4. Mokdad AH, Marks JS, Stroup DF, et al. Actual causes of death in the United States, 2000. *JAMA.* 2004 Mar 10;291(10):1238-45. PMID: 15010446.
5. Hymel PA, Loeppke RR, Baase CM, et al. Workplace health protection and promotion: a new pathway for a healthier--and safer--workforce. *J Occup Environ Med.* 2011 Jun;53(6):695-702. PMID: 21654443.
6. Centers for Disease Control and Prevention. Total Worker Health™. Atlanta, GA: CDC; 2013 August 20. www.cdc.gov/niosh/twh/. Accessed December 16, 2014.
7. World Health Organization. Jakarta Statement on Healthy Workplaces. Geneva, Switzerland: World Health Organization; 1997 www.who.int/healthpromotion/conferences/previous/jakarta/statements/workplaces/en/. Accessed May 6, 2015.
8. National Institute for Occupational Safety and Health (NIOSH). Research Compendium: The NIOSH Total Worker Health™ Program: Seminal Research Papers. Publication No. 2012-146. Washington, DC: U.S. Department of Health and Human Services PHS, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH); May 2012.
9. Sorensen G, McLellan D, Dennerlein JT, et al. Integration of health protection and health promotion: rationale, indicators, and metrics. *J Occup Environ Med.* 2013 Dec;55(12 Suppl):S12-8. PMID: 24284762.
10. Okechukwu CA, Krieger N, Sorensen G, et al. MassBuilt: effectiveness of an apprenticeship site-based smoking cessation intervention for unionized building trades workers. *Cancer Causes Control.* 2009 Aug;20(6):887-94. PMID: 19301135.
11. Caspi CE, Dennerlein JT, Kenwood C, et al. Results of a pilot intervention to improve health and safety for health care workers. *J Occup Environ Med.* 2013 Dec;55(12):1449-55. PMID: 24270297.
12. Porru S, Donato F, Apostoli P, et al. The utility of health education among lead workers: the experience of one program. *Am J Ind Med.* 1993 Mar;23(3):473-81. PMID: 8503465.
13. Pronk NP. Integrated worker health protection and promotion programs: overview and perspectives on health and economic outcomes. *J Occup Environ Med.* 2013 Dec;55(12 Suppl):S30-7. PMID: 24284747.
14. Anger WK, Elliot DL, Bodner T, et al. Effectiveness of Total Worker Health interventions. *J Occup Health Psychol.* 2015;20(2):226-47. PMID: 2014-55995-001.
15. National Institutes of Health. Pathways to Prevention Program. Bethesda, MD: Division of Program Coordination, Planning, and Strategic Initiatives, National Institutes of Health 2015 February 26, 2015. <https://prevention.nih.gov/programs-events/pathways-to-prevention>. Accessed March 8, 2015.
16. United Nations Development Programme (UNDP). Human Development Report 2014 - Sustaining Human Progress: Reducing

- Vulnerabilities and Building Resilience. UNDP; 2014 <http://hdr.undp.org/en/2014-report>.
17. Agency for Healthcare Research and Quality. Methods Guide for Effectiveness and Comparative Effectiveness Reviews. Agency for Healthcare Research and Quality AHRQ Publication No. 10(14)-EHC063-EF. Rockville, MD: January 2014. Chapters available at: www.effectivehealthcare.ahrq.gov.
 18. Berkman ND, Lohr KN, Ansari M, et al. Grading the Strength of a Body of Evidence When Assessing Health Care Interventions for the Effective Health Care Program of the Agency for Healthcare Research and Quality: An Update. Methods Guide for Effectiveness and Comparative Effectiveness Reviews (Prepared by the RTI-UNC Evidence-based Practice Center under Contract No. 290-2007-10056-I) AHRQ Publication No. 13(14)-EHC130-EF. Rockville, MD: Agency for Healthcare Research and Quality; January 2013. Chapters available at: www.effectivehealthcare.ahrq.gov.
 19. Systematic Review Data Repository. Accessed at <http://srdhr.ahrq.gov/> (June 30, 2015).
 20. Sorensen G, Stoddard AM, LaMontagne AD, et al. A comprehensive worksite cancer prevention intervention: behavior change results from a randomized controlled trial (United States). *J Public Health Policy*. 2003;24(1):5-25. PMID: 12760241.
 21. Lamontagne AD, Stoddard AM, Youngstrom RA, et al. Improving the prevention and control of hazardous substance exposures: a randomized controlled trial in manufacturing worksites. *Am J Ind Med*. 2005 Oct;48(4):282-92. PMID: 16142731.
 22. Hunt MK, Lederman R, Stoddard AM, et al. Process evaluation of an integrated health promotion/occupational health model in WellWorks-2. *Health Educ Behav*. 2005 Feb;32(1):10-26. PMID: 15642751.
 23. Maes S, Verhoeven C, Kittel F, et al. Effects of a Dutch work-site wellness-health program: the Brabantia Project. *Am J Public Health*. 1998 Jul;88(7):1037-41. PMID: 9663150.
 24. Palumbo MV, Wu G, Shaner-McRae H, et al. Tai Chi for older nurses: a workplace wellness pilot study. *Appl Nurs Res*. 2012 Feb;25(1):54-9. PMID: 20974089.
 25. Blackburn J, Brumby S, Willder S, et al. Intervening to improve health indicators among Australian farm families. *J Agromedicine*. 2009;14(3):345-56. PMID: 19657884.
 26. Tveito TH, Eriksen HR. Integrated health programme: a workplace randomized controlled trial. *J Adv Nurs*. 2009 Jan;65(1):110-9. PMID: 19032505.
 27. Sorensen G, Barbeau EM, Stoddard AM, et al. Tools for health: the efficacy of a tailored intervention targeted for construction laborers. *Cancer Causes Control*. 2007 Feb;18(1):51-9. PMID: 17186421.
 28. Sorensen G, Barbeau E, Stoddard AM, et al. Promoting behavior change among working-class, multiethnic workers: results of the healthy directions--small business study. *Am J Public Health*. 2005 Aug;95(8):1389-95. PMID: 16006422.
 29. Hunt MK, Barbeau EM, Lederman R, et al. Process evaluation results from the Healthy Directions-Small Business study. *Health Educ Behav*. 2007 Feb;34(1):90-107. PMID: 16740502.
 30. Barbeau E, Roelofs C, Youngstrom R, et al. Assessment of occupational safety and health programs in small businesses. *Am J Ind Med*. 2004 Apr;45(4):371-9. PMID: 15029570.
 31. Nieuwenhuijsen ER. Health behavior change among office workers: an exploratory study to prevent repetitive strain injuries. *Work*. 2004;23(3):215-24. PMID: 15579930.
 32. Hodges LC, Harper TS, Hall-Barrow J, et al. Reducing overall health care costs for a city municipality: a real life community based

- learning model. AAOHN J. 2004 Jun;52(6):247-53. PMID: 15219111.
33. Allen HM, Jr., Borden ST, Pikelny DB, et al. An intervention to promote appropriate management of allergies in a heavy manufacturing workforce: evaluating health and productivity outcomes. J Occup Environ Med. 2003 Sep;45(9):956-72. PMID: 14506339.
34. Sorensen G, Stoddard A, Hunt MK, et al. The effects of a health promotion-health protection intervention on behavior change: the WellWorks Study. Am J Public Health. 1998 Nov;88(11):1685-90. PMID: 9807537.
35. Sorensen G, Stoddard A, Ockene JK, et al. Worker participation in an integrated health promotion/health protection program: results from the WellWorks project. Health Educ Q. 1996 May;23(2):191-203. PMID: 8744872.
36. Sorensen G, Himmelstein JS, Hunt MK, et al. A model for worksite cancer prevention: integration of health protection and health promotion in the WellWorks Project. Am J Health Promot. 1995 Sep-Oct;10(1):55-62. PMID: 10155659.
37. Boggild H, Jeppesen HJ. Intervention in shift scheduling and changes in biomarkers of heart disease in hospital wards. Scand J Work Environ Health. 2001 Apr;27(2):87-96. PMID: 11409601.
38. Eriksen HR, Ihlebaek C, Mikkelsen A, et al. Improving subjective health at the worksite: a randomized controlled trial of stress management training, physical exercise and an integrated health programme. Occup Med (Lond). 2002 Oct;52(7):383-91. PMID: 12422025.
39. Olson R, Wright RR, Elliot DL, et al. The COMPASS pilot study: a total worker health intervention for home care workers. J Occup Environ Med. 2015 Apr;57(4):406-16. PMID: 25654631.
40. Olson R, Anger WK, Elliot DL, et al. A new health promotion model for lone workers: results of the Safety & Health Involvement For Truckers (SHIFT) pilot study. J Occup Environ Med. 2009 Nov;51(11):1233-46. PMID: 19858740.
41. Wipfli B, Olson R, Koren M. Weight-loss maintenance among SHIFT pilot study participants 30-months after intervention. J Occup Environ Med. 2013 Jan;55(1):1-3. PMID: 23291953.
42. Maniscalco P, Lane R, Welke M, et al. Decreased rate of back injuries through a wellness program for offshore petroleum employees. J Occup Environ Med. 1999 Sep;41(9):813-20. PMID: 10491798.
43. Barbeau EM, Li Y, Calderon P, et al. Results of a union-based smoking cessation intervention for apprentice iron workers (United States). Cancer Causes Control. 2006 Feb;17(1):53-61. PMID: 16411053.
44. von Thiele Schwarz U, Augustsson H, Hasson H, et al. Promoting employee health by integrating health protection, health promotion, and continuous improvement: a longitudinal quasi-experimental intervention study. J Occup Environ Med. 2015 Feb;57(2):217-25. PMID: 25654524.
45. Bureau of Labor and Statistics. Employment by Major Occupational Group. Washington, DC: Bureau of Labor Statistics, U.S. Department of Labor; 2012 19 December, 2013. http://www.bls.gov/emp/ep_table_101.htm. Accessed 10 August, 2015.
46. Community Preventive Services Task Force. Recommendations for worksite-based interventions to improve workers' health. Am J Prev Med. 2010 Feb;38(2S):S232-6.
47. Schulz KF, Altman DG, Moher D, et al. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. BMJ. 2010;340:c332. PMID: 20332509.
48. Taljaard M, Weijer C, Grimshaw JM, et al. The Ottawa Statement on the ethical design and conduct of cluster randomised trials: précis for researchers and research ethics committees. BMJ. 2013;346:f2838. PMID: 23661113.
49. Elliot DL, Goldberg L, Kuehl KS, et al. The PHLAME (Promoting Healthy Lifestyles: Alternative Models' Effects) firefighter study: outcomes of two models of behavior

- change. *J Occup Environ Med.* 2007 Feb;49(2):204-13. PMID: 17293760.
50. Atkins D, Chang SM, Gartlehner G, et al. Assessing applicability when comparing medical interventions: AHRQ and the Effective Health Care Program. *J Clin Epidemiol.* 2011 Nov;64(11):1198-207. PMID: 21463926.
51. Sommers BD, Gunja MZ, Finegold K, et al. Changes in Self-reported Insurance Coverage, Access to Care, and Health Under the Affordable Care Act. *JAMA.* 2015 Jul 28;314(4):366-74. PMID: 26219054.

Introduction

Background

The American worksite has been a venue for both health protection and health promotion programs. Health protection programs are interventions aimed specifically at preventing occupational injuries or illnesses. Work-related injuries and illnesses lead to morbidity, mortality, and considerable financial and social costs.¹⁻³ Health promotion (HP) programs, often called wellness programs, are interventions aimed at improving individual health behaviors and personal health. They address modifiable behavior risk factors such as smoking, physical activity, and diet, which are leading causes of morbidity and mortality in the United States.⁴

Traditionally, occupational safety and health (OSH) programs and HP programs have functioned independently within the workplace.⁵ In the past decade, however, interest in integrating these programs has grown appreciably.⁵⁻⁷ The National Institute for Occupational Safety and Health (NIOSH) focused attention on integrated approaches in 2011 by creating the Total Worker Health™ (TWH) program. NIOSH summarized the rationale for integrating health protection and health promotion interventions as follows:⁸

- Workers' risk of disease is increased by exposures to both occupational hazards and risk-related behaviors.
- The workers at highest risk for exposure to hazardous working conditions are also those most likely to engage in risk-related health behaviors.
- Integrating worksite HP and OSH may increase program participation and effectiveness for high-risk workers.
- Integrating occupational health and safety with worksite health promotion may also benefit the broader work organization and environment.

Total Worker Health is the “strategic and operational coordination of policies, programs, and practices designed to simultaneously prevent work-related injuries and illnesses, and enhance overall workforce health and well-being.”⁹ TWH is a trademarked term that was not commonly used in past studies of integrated interventions. For this review, we use the term “TWH interventions” to refer to integrated interventions that are consistent with NIOSH’s TWH™ initiative.

TWH interventions are often multicomponent interventions that pair organizational changes or policies with individualized content focused on a specific occupational hazard and one or more health behaviors or risk factors for chronic disease. These interventions include, for example, large-scale, company-wide programs and programs addressing outcomes relevant to workplace health and risk factors for chronic diseases. For example, some programs focus on reducing or eliminating exposure to both tobacco and workplace chemicals;¹⁰ reducing musculoskeletal disorders and fostering physical fitness at the individual and environmental levels;¹¹ and integrating information about individual lifestyle and safety health behaviors to reduce occupational lead exposure.¹²

Existing Guidelines

NIOSH guidelines to employers for implementing TWH™ programs comprise several documents.^{8,13-16} The guidelines focus on a considerable number of factors. They include the importance of organizational leadership and commitment; employee participation; needs assessment; planning; integrated objectives; integrated implementation teams; data integration

across health protection and health promotion systems; adequate resources; and solutions based on both organizational and individual factors. They also recommend use of participation incentives and provisions to ensure accountability, evaluation, and continual improvement.

Rationale for Evidence Review

The goal of this review is to identify gaps in the evidence about TWH effectiveness to help identify future research priorities. Previous reviews of the literature have used different search and inclusion criteria, resulting in included studies of varied rigor and scope.^{17,18} Moreover, the effectiveness of the interventions in individual studies and in the prior reviews has been judged based on various metrics (e.g., various improvements in health behaviors, physiologic outcomes and economic outcomes, or a count of the number of significant outcomes). As a result, uncertainty remains about the impact of TWH interventions on specific health and safety outcomes.

The authors of these studies and reviews also did not address all the key questions broached in this systematic review. For example, intervention effectiveness has not been considered in relation to the occupational groups, industries, and settings in which the interventions take place. Uncertainty also remains about the role of many contextual factors that affect worker safety and health (e.g., health care coverage, company size and unionization) as a modifier of intervention effectiveness. For example, small employers, which often do not offer health insurance, may struggle to provide comprehensive integrated interventions. In addition, more studies may have been conducted since the previous reviews and need to be added to the body of evidence. These factors underscore the need for the current systematic review to synthesize the literature supporting TWH interventions, assess the strength of evidence for important outcomes, and highlight research gaps and future research needs.

Scope and Key Questions

The purpose of this review is to provide an evidence report that the Pathways to Prevention Workshop Program of the Office of Disease Prevention at the National Institutes of Health (NIH) can use to inform a workshop focused on TWH.¹⁹ This review will describe the body of evidence evaluating TWH interventions, evaluate the effectiveness of TWH interventions for improving health and safety outcomes, highlight the research gaps, and inform future research needs. The Pathways to Prevention Workshop Program Panel will use the evidence report as a resource to develop a summary of the current state of the science and future research needs related to TWH interventions.

Specifically, we address the following five Key Questions (KQs):

Key Question 1

What populations, work settings, intervention types, and outcomes have been included in studies assessing integrated interventions?

Key Question 2

What is the effectiveness of integrated interventions for improving the following outcomes, and what are the potential harms?

- a. Health and safety outcomes (e.g., cardiovascular events or incidence of work-related injuries)

- b. Intermediate outcomes (e.g., change in blood pressure, tobacco use, or hazardous exposures)
- c. Utilization outcomes and occupational injury and illness surveillance outcomes (e.g., hospitalizations or measures of workers' compensation claims)
- d. Harms (e.g., discrimination or victim blaming).

Key Question 3

What are the characteristics of effective integrated interventions?

Key Question 4

What contextual factors have been identified as potential modifiers of effectiveness in studies of integrated interventions?

Key Question 5

What evidence gaps exist in the body of literature assessing the effectiveness of integrated interventions in terms of the following: populations, work settings, intervention types, outcomes, study designs, research methods, and contextual factors that may modify intervention effectiveness?

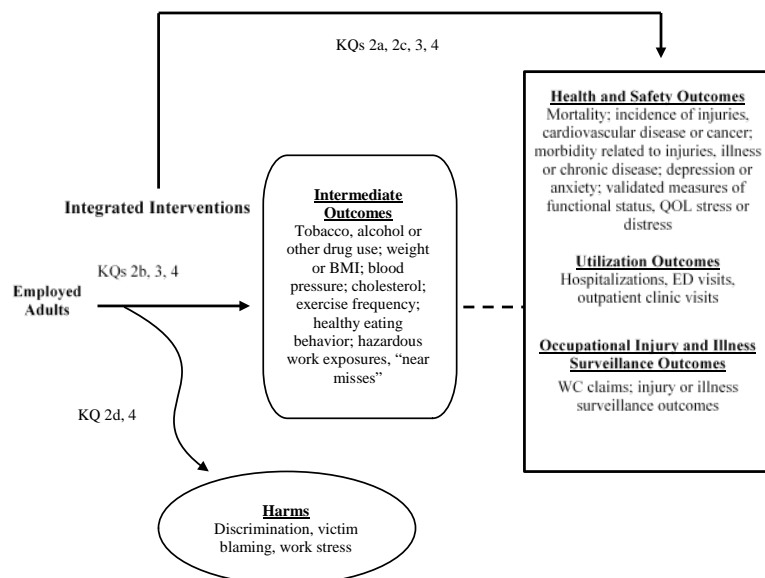
Key Question 6

What are the future research needs?

Analytic Framework

We developed an analytic framework to guide the systematic review process (Figure 1). The analytic framework illustrates the population, interventions, outcomes, and adverse effects that guided our literature search and synthesis.

Figure 1. Analytic framework for Total Worker Health™ interventions



BMI = body mass index; ED = emergency department; KQ = key question; QOL = quality of life; WC = workers' compensation.

Organization of This Report

The remainder of the review describes our methods in detail and presents the results of our synthesis of the literature with summary tables and the strength-of-evidence grades for major outcomes eligible for KQ2. The discussion section offers our conclusions, summarizes our findings, and provides other information relevant to the interpretation of this work for practice and future research. References and a list of acronyms and abbreviations follow the discussion section.

Appendix A contains the exact search strings we used in our literature searches. Studies excluded at the stage of reviewing full-text articles with reasons for exclusion are listed in Appendix B. Appendix C provides the specific questions used for evaluating the risk of bias of all included studies eligible for KQ2 (i.e., studies with a concurrent comparison group), documents risk of bias ratings for each study, and explains the rationale for high or medium ratings. Appendix D presents information about our grading of the strength of the various bodies of evidence (tables for individual domain assessments and overall strength-of-evidence grades for each outcome). Appendix E contains a reference list of studies in progress that are relevant to TWH interventions.

Methods

The methods for this review of Total Worker Health™ (TWH) interventions follow those specified for the Agency for Healthcare Research and Quality (AHRQ) Evidence-based Practice Center (EPC) program. This guidance is codified in the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews* (hereafter, *Methods Guide*, available at <http://www.effectivehealthcare.ahrq.gov/methodsguide.cfm>).

Topic Refinement and Protocol Review

The purpose of this review is to provide an evidence report that the Pathways to Prevention Workshop Program of the Office of Disease Prevention at the National Institutes of Health (NIH) can use to inform a workshop focused on TWH.¹⁹ The initial Key Questions were provided by the Pathways to Prevention (P2P) Working Group of the National Institutes of Health (NIH). The RTI-UNC EPC further refined the Key Questions (KQs). We incorporated guidance from a Technical Expert Panel (TEP) into the final research protocol, which was posted on the AHRQ Website on May 26, 2015, at: <http://www.effectivehealthcare.ahrq.gov/search-for-guides-reviews-and-reports/?pageaction=displayproduct&productid=2085>.

Literature Search Strategy

Search Strategy

We searched MEDLINE®, the Cochrane Library, the Cochrane Central Trials Registry, and PsycInfo from January 1, 1990, to March 26, 2015. Appendix A presents the full search strategy. Its start date (January 1, 1990) reflects the timing of increased attention and focus on “integrated” interventions. A review of TWH background documents from the National Institute of Occupational Safety and Health (NIOSH), previously published narrative reviews, and our literature scan indicates that the majority of programs began after 1990. We will complete a second (update) search during peer review.

We used either Medical Subject Headings (MeSH) or major headings as search terms when available or key words when appropriate, focusing on terms to describe the relevant population and interventions of interest. We reviewed our search strategy with the Technical Expert Panel (TEP) and incorporated their input into our search strategy. An experienced information scientist (an EPC librarian) conducted the searches. We conducted quality checks to ensure that our searches identified known studies (i.e., studies identified on NIOSH’s TWH website and expert reviews focused on integrated interventions).

We searched for unpublished studies relevant to this review using ClinicalTrials.gov and Academic Search Complete; on our behalf, the AHRQ Scientific Resource Center solicited scientific information packages via Federal Register notices or informational requests. We received a bibliography from NIOSH listing studies relevant to the TWH program. We used this bibliography to ensure that our database searches had not missed relevant citations.

We also manually searched reference lists of pertinent reviews, included trials, and background articles on this topic to look for any relevant citations that our searches might have missed. We imported all citations into an EndNote® X7 electronic database.

Inclusion and Exclusion Criteria

We developed eligibility (inclusion and exclusion) criteria with respect to PICOTS (populations, interventions, comparators, outcomes, timeframes, settings), study designs, and study durations for each KQ (Table 1). The focus of this review is on providing an overall synthesis of TWH or “integrated” interventions. We cast a broad net and included any studies focused on interventions that could be considered integrated based on the intervention criteria outlined in Table 1.

We did not exclude any categories of workers or studies based on the type of outcomes reported. For KQ 2, we limited our evidence synthesis to commonly reported outcomes that are considered to be important measures of worker health and safety. We chose these outcomes by reviewing prior studies of TWH interventions and asking for input from TEP on our inclusion and exclusion criteria before finalizing the research protocol.

Table 1. Inclusion/exclusion criteria for studies of Total Worker Health™ Interventions

PICOTS	Inclusion	Exclusion
Population	Employed adults (18 years of age or older)	Children and adolescents under age 18
Intervention	Any “integrated intervention” that meets the definition of a TWH strategy, defined as “a strategic and operational coordination of policies, programs, and practices designed to simultaneously prevent work-related injuries and illnesses, and enhance overall workforce health and well-being.” ⁹ We will not judge inclusion and exclusion based on the degree or type of integration. ^a To meet inclusion criteria, an intervention must include a component aimed specifically at improving workplace health and safety ^b and a component aimed at improving overall health, health behaviors, or risk factors for chronic diseases ^c Interventions may include a range of components that focus on changes in policy, organizational structure, work organization, environmental factors, or individual worker education, counseling, training, or social support (or combinations of these components)	All other interventions
Comparator	All KQs: Usual practice, usual care, standard care, or no intervention; head-to-head studies comparing two different TWH interventions KQ 1 only: Pre-post comparisons (in addition to the comparators listed above)	No comparison; nonconcordant historical controls
Outcomes	KQ 1: This is a descriptive summary of studies that meet inclusion criteria for all other domains (e.g., intervention and study design criteria); we will describe the range of outcomes reported across trials (in addition to the ones listed below for KQs 2, 3, and 4). KQ 2a: Health and safety outcomes: Mortality; incidence of injuries, cardiovascular disease, or cancer; morbidity related to injuries, illnesses, or chronic disease (including work-related injuries and illnesses); depression or anxiety; validated measures of functional status, quality of life, stress or distress	KQs 2, 3, 4: All other outcomes, such as measures of aerobic capacity (e.g., VO ₂ max) or exercise performance (e.g., number of sit-ups performed); intake of specific foods or dietary components (e.g., fat intake); measures of self-efficacy; participation in specific health promotion or safety programs (that are separate from the intervention); economic evaluation outcomes (e.g., cost or return on investment); work productivity measures (e.g., absenteeism)

Table 1. Inclusion/exclusion criteria for studies of Total Worker Health® Interventions (continued)

PICOTS	Inclusion	Exclusion
	<p>KQ 2b: Intermediate outcomes: Tobacco, alcohol, or illicit drug use; weight or body mass index (BMI); blood pressure; cholesterol (total cholesterol, LDL cholesterol and HDL cholesterol); incidence of diabetes; frequency of physical activity; healthy eating behavior (e.g., increased consumption of fruit and vegetables); rates of hazardous exposures or “near misses”</p> <p>KQ 2c: Utilization outcomes and Occupational Injury and Illness surveillance outcomes: Hospitalizations, emergency department visits, or outpatient clinic visits; measures of workers’ compensation claims or injury or illness surveillance outcomes</p> <p>KQ 2d: Harms: Increased barriers to reporting work-related injuries or illnesses, work stress, adverse effects on personal health, discrimination, victim-blaming</p> <p>KQ 3: This is a descriptive summary of interventions that are effective for improving a health and safety outcome or an intermediate outcome (from our KQ 2 analysis).</p> <p>KQ 4: This is a descriptive summary of contextual factors identified as potential modifiers of intervention effectiveness across all included studies. Contextual factors may include (but are not limited to) the following: legal-regulatory environment (e.g., state laws with respect to union representation); employer characteristics, policies, or benefits (e.g., availability of health insurance coverage or paid sick leave); work organization (e.g., shift work); and social or economic factors (e.g., income or availability of community resources to support or promote health).</p> <p>KQs 5, 6: These entail a descriptive summary of, respectively, research gaps and future research needs related to TWH interventions.</p>	
Timing	Any duration of followup	None
Setting	Studies conducted in any workplace setting in a developed country (“very high” human development index per the United Nations Development Programme) ²⁰	Studies conducted in other countries
Study designs	<p>All KQs: Original research, including RCTs, nonrandomized controlled trials, prospective cohort studies with a concurrent control group</p> <p>KQ 1: Pre-post cohort studies without a control group (in addition to the study designs listed above)</p>	All other designs including case reports, case series, retrospective cohort studies, nonsystematic reviews, systematic reviews, studies with historical (rather than concurrent) control groups

^a Variations in the degree to which interventions are “integrated” and how integration is accomplished, as well as the specific intervention components included, are considered characteristics of the integrated interventions and are the focus of KQ 1 (characteristics of interventions) and KQ 3 (characteristics of effective interventions).

^b Occupational Safety and Health: Intervention (or program) components aimed at reducing hazardous exposures at work that can lead to work-related injury, illness and disability. Interventions can be at the organizational or individual level (or both). Examples include (but are not limited to) the following: employer policies to improve (or remove) work hazards; engineering

controls designed to eliminate or substitute hazards; adoption of improved personal protective equipment; individual-level health and safety training to employees

^c Worksite Health Promotion: Intervention (or program) components aimed at promoting worker health through reduction of individual risk-related behaviors such as tobacco use, substance use, sedentary lifestyle, poor nutrition, stressors, and other preventable health behaviors. Intervention components may incorporate employee assistance programs, clinical prevention services, disease management programs and other health benefits. Interventions may also include community-based services (e.g., referral for community-based health services) or environmental changes (e.g., increasing access to health foods at a worksite)

HDL= high density lipoprotein; KQ = Key Question; LDL = low density lipoprotein; PICOTS = populations, interventions, comparators, outcomes, timing, and setting; RCT = randomized controlled trial; TWH = Total Worker Health; VO₂ max = maximal rate of oxygen consumption as measured during incremental exercise.

Study Selection

Two members of the research team independently reviewed all titles and abstracts (identified through searches) for eligibility against our inclusion/exclusion criteria (Table 1). We retrieved any publications marked for inclusion by either reviewer for evaluation of the full text. For titles and abstracts that lacked adequate information to determine inclusion or exclusion, we retrieved the full text for review. Then, two investigators independently reviewed the full texts to determine final inclusion or exclusion. The reviewers resolved any disagreements by discussion and consensus or by consulting a third member of the review team.

All results in both review stages were tracked in an EndNote® database. We recorded the principal reason that each excluded full-text publication did not satisfy the eligibility criteria (Appendix B).

Data Extraction

For studies that met our inclusion criteria, we designed and used structured data extraction forms to gather pertinent information from each article, including characteristics of study populations, settings, interventions, comparators, study designs, methods, and results. One investigator extracted the relevant data from each included article; all data abstractions were reviewed for completeness and accuracy by a second member of the team. We recorded intention-to-treat (ITT) results if available. All data abstraction was performed using Microsoft Excel® software. Once the final report is published online on the AHRQ Website, we will upload all abstracted data to AHRQ's Systematic Review Data Repository (SRDR) for use in future research.²¹

Risk of Bias Assessment of Individual Studies

To assess the risk of bias (internal validity) of studies eligible for KQ 2, we used predefined criteria based on the AHRQ *Methods Guide*. These criteria included questions to assess selection bias, confounding, performance bias, detection bias, and attrition bias (i.e., those about adequacy of randomization, allocation concealment, similarity of groups at baseline, masking, attrition, use of ITT analysis, method of handling dropouts and missing data, reliability and validity of outcome measures, and treatment fidelity).²² Appendix C lists the specific questions used for evaluating the risk of bias of all included studies. It also includes a table showing the responses to these questions and risk of bias ratings for each study and explains the rationale for all ratings that were either high or medium. As with our abstracted data, we will upload risk of bias ratings for the review's included studies to SRDR.²¹

In general terms, results from a low risk of bias study are considered to be valid. A study with medium risk of bias is susceptible to some risk of bias but probably not enough to invalidate

its results. A study assessed as high risk of bias has significant risk of bias (e.g., stemming from serious errors in design, conduct, or analysis) that may invalidate its results. To assess publication bias, we looked for evidence of unpublished literature through searches of gray literature (clinicaltrials.gov). We also reviewed (when available) the original protocols for included trials to assess for selective outcome reporting.

We determined the risk of bias rating using the responses to all questions assessing the various types of bias listed above. To receive a low risk of bias rating, we required favorable responses to most questions, and any unfavorable responses had to be relatively minor (e.g., minor baseline differences between study groups unlikely to bias the results). We gave high risk of bias ratings to studies that we determined to have a major methodological shortcoming in one or more categories based on our qualitative assessment. Common methodological shortcomings contributing to high risk of bias ratings were high rates of attrition or differential attrition, inadequate methods used to handle missing data, and baseline differences between intervention and control groups that were not addressed in the analysis. We describe the results of all included studies for KQ 2 regarding of the risk of bias rating.

Two independent reviewers assessed the risk of bias for each study. Disagreements between reviewers were resolved by discussion and consensus or by consulting a third member of the team.

Data Synthesis

We did not perform any meta-analyses because of the heterogeneity across studies in terms of included populations, interventions, and outcomes. We summarized all included studies in narrative form and in summary tables that tabulate the important features of the study populations, design, intervention, outcomes, and results for KQ 1 and KQ 2.

KQ 3 asks primarily “What are the characteristics of effective interventions?” The aim of KQ 3 was to describe the characteristics of effective interventions; it is intended as a descriptive question to provide information about the interventions that work for employers or researchers who may want to implement or design TWH interventions. To address this question, we extracted detailed information on intervention components (described in KQ 1). We then focused on characteristics that relate to two main domains: (1) approach to integration (e.g., organizational integration across departments responsible for occupational safety and health and health promotion, employee participation, and other factors) and (2) specific content of the intervention in terms of both (a) occupational safety and health (OSH) components (e.g., administrative controls to improve or remove work hazards or individual education related to work hazards) and (b) health promotion (HP) components (e.g., environmental changes or individual education to promote healthy behavior). We describe common components and combinations of components for all interventions that were effective for improving any outcome eligible for KQ 2 (at least low strength of evidence for benefit).

For KQ 4, we compiled contextual factors identified in included studies as potential modifiers of effectiveness. Finally, KQ 5 and KQ 6 focus on evidence gaps in terms of PICOTS and future research needs, respectively.

Strength of the Body of Evidence

We graded the strength of evidence (SOE) of the accumulated evidence on a given issue to answer the specific KQs on the benefits and harms of the interventions in this review; we used the guidance established for the EPC program.²³ Developed to grade the overall strength of a

body of evidence, this approach now incorporates five key domains: study limitations (including study design and aggregate risk of bias), consistency, directness, and precision of the evidence, and reporting bias. It also considers other optional domains that may be relevant for some scenarios, such as plausible confounding that would decrease the observed effect and strength of association (i.e., magnitude of effect).

Table 2 describes the grades of evidence that can be assigned. Grades reflect the strength of the body of evidence to answer outcomes relevant to KQ 2 (comparative effectiveness, efficacy, and harms of the interventions in this review). Two reviewers assessed each domain for each key outcome, and differences were resolved by consensus. For each assessment, one of the two reviewers was always an experienced EPC investigator.

Table 2. Definitions of the grades of overall strength of evidence

Grade	Definition
High	We are very confident that the estimate of effect lies close to the true effect for this outcome. The body of evidence has few or no deficiencies. We believe that the findings are stable, i.e., another study would not change the conclusions.
Moderate	We are moderately confident that the estimate of effect lies close to the true effect for this outcome. The body of evidence has some deficiencies. We believe that the findings are likely to be stable, but some doubt remains.
Low	We have limited confidence that the estimate of effect lies close to the true effect for this outcome. The body of evidence has major or numerous deficiencies (or both). We believe that additional evidence is needed before concluding either that the findings are stable or that the estimate of effect is close to the true effect.
Insufficient	We have no evidence, we are unable to estimate an effect, or we have no confidence in the estimate of effect for this outcome. No evidence is available or the body of evidence has unacceptable deficiencies, precluding reaching a conclusion.

Source: Berkman et al.²³

An unfavorable assessment for any one of the four key domains (e.g., inconsistency, indirectness, imprecision, or medium aggregate risk of bias) typically resulted in downgrading from high to moderate SOE. Two unfavorable assessments typically resulted in downgrading to low SOE. When only one study reported an outcome of interest (with unknown consistency and imprecision), we usually graded the SOE as insufficient; when similar interventions had consistent results in different populations of workers or at different outcome timings we graded the SOE as low. Appendix E presents tables showing our assessments for each domain and the resulting SOE grades for outcomes eligible for KQ 2, organized by outcome category.

Applicability

We assessed applicability of the evidence following guidance from the *Methods Guide*.²⁴ We used the PICOTS framework to explore factors that affect applicability. Some factors identified a priori that may limit the applicability of evidence include the following: geographic setting, work setting (industry and worksite), occupation (and associated occupational hazards) of enrolled populations, sex of enrolled populations (e.g., few women may be enrolled in the studies), and race or ethnicity of enrolled populations.

Peer Review and Public Commentary

This report will be posted for public comment and peer reviewed. We will address all comments in the final report, making revisions as needed; a disposition of comments report will be publicly posted 3 months after release of the final report.

Results

Introduction

This chapter presents the results of our systematic review. We first present the results of our literature searches and identify studies that met our inclusion criteria (referred to as “included studies”). We then discuss the findings from our analyses for each Key Question (KQ), starting with an overview of key points and then synthesizing the results. KQ 1 describes in detail all included studies by work settings and populations, intervention and outcomes. A subset of included studies (i.e., studies with a concurrent control group) was eligible for KQ 2, which focuses on the effectiveness and harms of Total Worker Health™ (TWH) interventions.

For KQ 2, we present the results of included studies organized by outcome category: health and safety outcomes; intermediate outcomes; utilization outcomes (including occupational injury and illness surveillance outcomes); and harms. When no study reported on a specific outcome eligible for KQ 2, we note this gap in the key points section of results but do not list the outcome header in the detailed KQ 2 synthesis. For each outcome, we briefly describe the population, work setting, and intervention characteristics of the studies reporting a specific outcome. We describe the results of all studies eligible for KQ 2, regardless of the risk of bias rating. However, as described in the Methods chapter, we graded the strength of evidence (SOE) only for outcomes reported by at least one study that we had rated as either low or medium risk of bias.

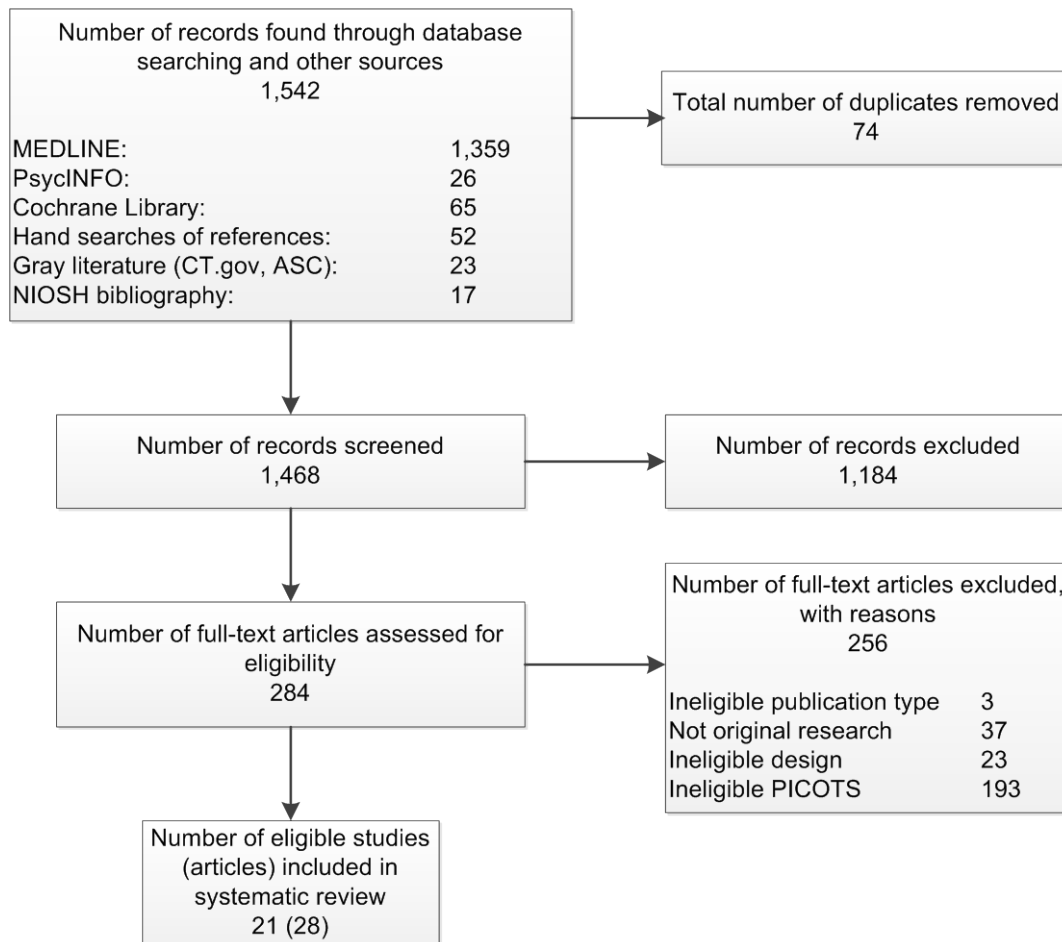
For KQ 3, we describe the components of effective interventions when we had least one study rated as low or medium risk of bias that showed benefit for an included outcome in KQ 2. We focus on components of interventions relating to the integration of health promotion (HP) and occupational safety and health (OSH).

The results of KQs 4-6 are based on all included studies, regardless of whether they were eligible for KQ 2. KQ 4 describes contextual factors that authors noted as potential modifiers of intervention effectiveness (e.g., employer characteristics, work organization, of social and economic factors). Finally, KQ 5 and KQ 6 outline research gaps and future research needs (respectively) relevant to TWH interventions.

Results of Literature Search and Screening

Searches of all sources identified a total of 1,496 potentially relevant citations. We included 21 studies described in 28 publications.^{10-12,25-49} Figure 2 describes the flow of literature through the screening process according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) categories.⁵⁰ Appendix B provides a complete list of articles excluded at the full-text screening stage, with reasons for exclusion. Of the 21 included studies, 12 studies had a concurrent control group and were also eligible for KQ 2.^{10,25,28,29,31-33,38,39,42,43,49} Table 3 lists studies assessed for each KQ.

Figure 2. Disposition of articles for Total Worker Health™ interventions



ASC = Academic Search Complete; CT.gov = ClinicalTrials.gov; NIOSH = National Institute of Occupational Safety and Health; PICOTS = populations, interventions, comparators, outcomes, timeframes, settings.

Table 3. Included studies, by KQ eligibility and KQ 2 outcomes

Author, Year, Study Design, Risk of Bias	KQ 1	Outcomes Eligible for KQ 2 ^a	KQ3	KQ4	KQ5	KQ6
Allen et al., 2003 ³⁸ NRCT, High	Y	Allergy severity WC claims Short-term disability claims	N	Y	Y	Y
Barbeau et al., 2006 ⁴⁸ Single group re-post study, NA	Y	NA	N	Y	Y	Y
Blackburn et al., 2009 ³⁰ Single-group pre-post study, NA	Y	NA	N	Y	Y	Y
Boggild and Jeppesen, 2001 ⁴² Cohort study, High	Y	Alcohol consumption Cholesterol Exercise frequency Smoking cessation Harms	N	Y	Y	Y
Caspi et al., 2013 ¹¹ Single-group pre-post study, NA	Y	NA	N	Y	Y	Y

Table 3. Included studies, by KQ eligibility and KQ 2 outcome (continued)

Author, Year, Study Design, Risk of Bias	KQ 1	Outcomes Eligible for KQ 2 ^a	KQ3	KQ4	KQ5	KQ6
Eriksen et al., 2002 ⁴³ RCT, High	Y	Subjective health complaints Job Stress Harms	N	Y	Y	Y
Hodges et al., 2004 ³⁷ Single-group pre-post study, NA	Y	NA	N	Y	Y	Y
Maes et al., 1998 ²⁸ NRCT, High	Y	CVD risk score General Stress	N	Y	Y	Y
Maniscalco et al., 1999 ⁴⁷ Single-group pre-post study, NA	Y	NA	N	Y	Y	Y
Nieuwenhuijsen et al., 2004 ³⁶ Single-group pre-post study, NA	Y	NA	N	Y	Y	Y
Okechukwu et al., 2009 ¹⁰ RCT, High	Y	Smoking	N	Y	Y	Y
Olson et al., 2015 ⁴⁴ Single-group pre-post study, NA	Y	NA	N	Y	Y	Y
Olson et al., 2009 ^{45,46} Single-group pre-post study, NA	Y	NA	N	Y	Y	Y
Palumbo et al., 2012 ²⁹ RCT, High	Y	Quality of life (SF-36) General stress (PSS) Job stress (NSS) Functional status (WLQ)	N	Y	Y	Y
Porru et al., 1993 ¹² Single-group pre-post study, NA	Y	NA	N	Y	Y	Y
Sorensen et al., 1998 ³⁹⁻⁴¹ RCT, High	Y	Healthy eating Self-reported workplace carcinogenic hazard exposure Smoking cessation	N	Y	Y	Y
Sorensen et al., 2003 ²⁵⁻²⁷ RCT, High	Y	Healthy eating Hazardous substance exposure prevention ratings Smoking cessation	Y	Y	Y	Y
Sorensen et al., 2005 ³³⁻³⁵ RCT, Medium	Y	Healthy eating Physical activity	Y	Y	Y	Y
Sorensen et al., 2007 ³² RCT, Medium	Y	Healthy eating Smoking cessation	Y	Y	Y	Y
Tveito and Eriksen, 2009 ³¹ RCT, High	Y	Quality of life (SF-36) Subjective health complaints (SHC inventory) Harms	N	Y	Y	Y
von Thiele Schwarz et al., 2015 ⁴⁹ RCT, High	Y	Self-rated health ^b	N	Y	Y	Y

^a Other outcomes assessed in these studies are listed in Table 6 in KQ 1.

^b Self-rated health was assessed using a single item where participants were asked to rate their current health status on a five-point scale that ranged from “very good” (1) to “very poor” (5).

CVD = cardiovascular disease; KQ = Key Question; N = no; NA = not applicable; NRCT = non-randomized controlled trial; NSS = Nursing Stress Scale; PSS = Perceived Stress Scale; RCT = randomized controlled trial; SF-36 = Medical Outcomes Study Short Form (36 items); SHC = Subjective Health Complaints; WC = workers compensation; WLQ = Work Limitations Questionnaire; Y = yes.

KQ 1. Characteristics of Studies Evaluating Total Worker Health™ Interventions

We included 21 studies described in 28 publications that assessed integrated interventions; nine of the studies were randomized controlled trials (RCTs),^{10,25-27,29,31-35,39-41,43,49} two were nonrandomized controlled trials (NRCTs),^{28,38} one was a prospective cohort study,⁴² and nine

were single group pre-post studies.^{11,12,30,36,37,44-48} The nine single group pre-post studies were not eligible for KQ 2 (effectiveness and harms of integrated interventions) but we have included them here to give a full picture of the range of populations, work settings, intervention types, and outcomes that investigators have examined in assessments of integrated interventions. KQ 2 describes results (and gives strength of evidence grades for eligible outcomes) for the 12 studies that had a concurrent control group.

Across the 21 included studies, heterogeneity was substantial with respect to the work settings and populations, the intervention types, and the outcomes evaluated. Detailed information extracted from all included studies is available from the Systematic Review Data Repository™ (SRDR), available on the web at www.srdr.ahrq.gov.

Key Points: Work Settings and Populations

- The majority of studies enrolled workers from the manufacturing, construction and health care and social assistance industries.
- Workers from the manufacturing and construction industry were predominantly male and included a mix of blue-collar production workers and white-collar workers. Workers from the health care and social assistance industry were overwhelmingly female nurses.
- Commonly targeted workers were between 30 and 50 years of age; only one study evaluated a younger workforce (mean <30 years of age) and only one study evaluated an older workforce (mean >50 years of age).
- Few studies described the baseline health status or comorbidity of included populations.

Key Points: Interventions and Comparators

- All 21 studies assessed an intervention focused on an integrated objective in terms of addressing both OSH and HP. Eight studies also involved strategic integration across organizational departments responsible for OSH and HP. Fifteen studies involved worker participation in the development, design, planning, and/or implementation of the intervention. Five studies involved both strategic integration and workers participation.
- Most studies assessed complex multicomponent interventions; three studies assessed a single component aimed at both OSH and HP.
- Of the 21 included studies, only one assessed the effectiveness of integration alone (without added OSH or HP content). Eleven studies assessed interventions that included new, comprehensive HP and OSH components not previously available to workers. Six studies included mostly HP content that was tailored to the specific needs of workers (often by highlighting the potential synergistic toxicity of work hazards and health behavior) and three studies assessed interventions that focused more on OSH hazards but also included content aimed at promoting healthy behavior.
- Of the 21 studies, 12 included concurrent control groups, most of which received no intervention. Four studies included active control groups that received a HP component only.

Key Points: Outcomes

- Overall, the studies assessed diverse outcomes. Few included studies assessed the same outcomes in similar populations of workers.

- Approximately half of studies evaluated at least one final health outcome such as general physical or mental health (e.g., quality of life, functional status), subjective health complaints, and stress.
- Commonly reported intermediate health outcomes were BMI, biomarkers associated with risk of cardiovascular disease (e.g., cholesterol) and health behaviors, primarily physical activity, smoking, and dietary behaviors. Job stress was the most commonly reported OSH intermediate outcome.
- Few studies evaluated work-related injuries or illnesses.
- Several studies assessed outcomes that we did not include in KQ 2 (effectiveness and harms of TWH integrations); the most common were measures of absenteeism and economic evaluation outcomes.

Detailed Synthesis

Below we describe the characteristics of all included studies. First we describe the work settings and population characteristics. We then describe the characteristics of integrated interventions and the range of outcomes evaluated in studies.

Work Settings and Populations

Table 4 describes the characteristics of work settings and populations evaluated across included studies. The included studies primarily enrolled workers based on their occupation, (e.g., farmers, truckers) affiliation with a specific training program or union, work setting (e.g., hospitals, factories), specific geographic location. (e.g., municipal workers in a specific city), or combinations of these factors. No studies enrolled workers based on non-work related health status (e.g., comorbidity or risk factors for chronic diseases).

Table 4. Characteristics of work settings and populations

Author(s), Year Study Name	Industry Worksite(s) (N worksites; N workers) Country (States)	Occupational Group(s)	Mean Age ^a (SD), Years	% Female	% Non- white
Allen et al., 2003 ³⁸	Manufacturing	Blue-collar production workers and while-collar workers (% across worksites not reported)	43-46 (NR)	31	NR
International's Allergy Project	Worksites producing of medium- and heavy-duty trucks and diesel engines (7; 519)				
	United States (Illinois, Indiana)				
Barbeau et al., 2006 ⁴⁸	Construction	Apprentice iron workers	30 (8)	3	21
MassBUILT Pilot	Building trade apprentice training program (1; 337)				
	United States (Massachusetts)				
Blackburn et al., 2009 ³⁰	Agriculture	Farmers (cropping and grazing)	47 (8.8)	45	NR
Sustainable Farm Families Project	Communities in Southeastern Australia (NA; 128)				
	Australia				

Table 4. Characteristics of work settings and populations (continued)

Author(s), Year Study Name	Industry Worksite(s) (N worksites; N workers) Country (States)	Occupational Group(s)	Mean Age^a (SD), Years	% Female	% Non- white
Boggild and Jeppesen, 2001 ⁴²	Health Care and Social Assistance Inpatient wards (7) in a regional hospital (1; 374) Denmark	Nurses and nursing aides	35-42 (NR)	NR	NR
Caspi et al., 2013 ⁵¹	Health Care and Social Assistance Inpatient wards (7) in a teaching hospital (1; 374) United States (Massachusetts)	Nursing staff (advanced practice nurses, nurse leaders, and patient care associates)	41 (12)	90	21
Eriksen et al., 2002 ⁴³	Transportation Post office or postal terminal (31; 860) Norway	Postal service (office clerks and blue collar workers)	37-39 (NR)	59-64	NR
Hodges et al., 2004 ³⁷	Multiple Industries Various worksites employing municipal works in one city (NR; 900) City of North Little Rock Employee Health and Wellness Program United States (Arkansas)	Multiple (any municipal employee in North Little Rock, AK)	NR	NR	NR
Maes et al., 1998 ³⁸	Manufacturing Brabantia Project Producer of household goods (3 264) The Netherlands	Blue-collar production workers	39-41 (10.4- 10.5)	NR	NR
Maniscalco et al., 1999 ⁵²	Oil and gas extraction Offshore crude oil exploration facility (1; 147) Lafayette Offshore Business Unit Wellness Program (OBUWP) United States (Louisiana)	Production operators, platform repairmen (mechanical, electrical, and automation)	42 (NR)	10	NR
Nieuwenhuijse, 2004 ³⁶	Health Care and Social Service Administrative office of a Health Maintenance Organization (1; 40) Work Site Health Risk Project United States (Michigan)	Administrative support and clerical workers, management, and data entry/computer programmers	36 (range: 77 19-65)		NR
Okechukwu et al., 2009 ¹⁰	Construction Building trade apprentice training program (10; 1,8177) MassBUILT United States (Massachusetts)	Boilermakers; bricklayers; electricians; hoisting and portable engineers; ironworkers; painters; plumbers; pipefitters; sprinkler fitters; and refrigeration workers	28-29 (6.7-6.9)	4-6	15-18

Table 4. Characteristics of work settings and populations (continued)

Author(s), Year Study Name	Industry Worksite(s) (N worksites; N workers) Country (States)	Occupational Group(s)	Mean Age ^a (SD), Years	% Female	% Non- white
Olson et al., 2009, ⁴⁵ Wipfli et al., 2013 ⁴⁶ SHIFT Pilot Study	Transportation Carrier companies (4;29) United States (Pacific Northwest)	Truck drivers	48 (10)	21	3
Olson et al., 2015 ⁴⁴ Community of Practice and Safety Support (COMPASS)	Health Care and Service Home care workers residing near Portland, Oregon (NA; 16) United States (Oregon)	Home care workers	58 (8)	94	33
Palumbo et al., 2012 ²⁹	Health Care and Service Hospital (academic medical center) (1; 14) United States (Vermont)	Registered nurses, licensed practical nurses on hospital wards requiring patient lifting	NR	100	NR
Porru et al., 1993 ¹²	Manufacturing Small factories, including bronze and brass foundries, lead shot production facilities, and pylon painting factory (7; 50) Italy	Production workers with exposure to lead	39 (range: NR 21-58)	NR	NR
Sorensen et al., 1998; ³⁹ Sorensen et al., 1996; ⁴⁰ Sorensen et al., 1995 ⁴¹ WellWorks	Manufacturing Worksites producing industrial, chemical, and other products; textile dyeing; firefighting; and newspapers (24; 2,658) United States (Massachusetts)	Blue-collar production workers, firefighters, textile dying machine operators ^b	(%s) <35: 27 35-50: 51 >50: 23	24	<4
Sorensen et al., 2003; ²⁵ LaMontagne et al., 2005; ²⁶ Hunt et al., 2005 ²⁷ WellWorks-2	Manufacturing Worksites associated with probable use of hazardous chemicals (15; 9,019) United States (Massachusetts)	Blue collar- (hourly) and white-collar (salaried) workers	(%s) Under 31: 12-16 31-40: 27- 33 41-50: 28- 32 51-60: 19- 24 61-70: 4-5 71 or older: 0-1	34-43	15-22
Sorensen et al., 2005 ³³ , Hunt et al., 2007 ³⁴ , Barbeau et al., 2004 ³⁵ Healthy Directions- Small Business	Manufacturing Worksites producing medical equipment, dog food, specialty pumps, textiles, and electronic; and laundry and printing service providers (26; 1,740) United States (Massachusetts)	Blue-collar workers (83- 84%) and managers (16- 18%)	43-44 (NR)	25-44	18-25

Table 4. Characteristics of work settings and populations (continued)

Author(s), Year Study Name	Industry Worksite(s) (N worksites; N workers) Country (States)	Occupational Group(s)	Mean Age ^a (SD), Years	% Female	% Non- white
Sorensen et al., 2007 ³²	Construction	Laborers; general laborers; concrete workers; heavy construction workers; demolition workers; jackhammer (union members)	40-41 (9.5-9.7)	5-6	30-37
Tools for Health	Workers with membership in the Laborers' International Union of North America (LIUNA) (NA; 674) United States (multiple states)				
Tveito and Eriksen, 2009 ³¹	Health Care and Social Service Nursing home for older people (1; 40) Norway	Nursing auxiliaries, nurses, assistants, other helping staff	NR	100	NR
Von Thiele Schwarz et al., 2015 ⁴⁹	Health Care and Social Service Inpatient units (12) in a county hospital (1; 312) Sweden	Registered nurses, assistant nurses, others with direct patient care	45-47 (9.2-12.1)	91-96	NR

^a When only the mean age per study arm (e.g., intervention and control groups) is provided we present that as a range across groups.

^b More than half of the 24 worksites in the WellWorks study described as majority blue-collar workers, ranging from 52 percent of the workers at the high-volume battery manufacturing worksite to 98 percent of workers at the firefighting worksite; the investigators did not describe non-blue-collar workers in detail.

N = number (of participants or worksites); NA: not applicable; NR = not reported; SD = standard deviation.

Geographic Setting

Fourteen of the 21 included studies were conducted in the United States (US);^{10,11,25,29,32,33,36-39,44,45,47,48} six were conducted in Massachusetts^{10,25,33,39,48,53} 7 were conducted in various other states, including Vermont,²⁹ Illinois/Indiana,³⁸ Arkansas,³⁷ Louisiana,⁴⁷ Michigan,³⁶ Pacific Northwest⁴⁵ and Oregon⁴⁴). One study enrolled workers from multiple states based on their affiliation with a labor union.³² Of the studies conducted outside the US, 4 were set in Scandinavian countries (Norway, Denmark, Sweden)^{31,42,43,49}, and one study each was set in the Netherlands,²⁸ Italy,¹² and Australia.³⁰

Work Setting

The majority of studies included workers from the health care and social assistance, manufacturing and construction industries. The degree to which studies described characteristics of worksites (e.g., types of workplace exposures or union representation) varied across included studies.

Seven studies enrolled workers from the health care and social assistance industry. Six of these focused on worksites providing direct patient care; five focused on single worksites where workers are centralized (4 were set in a hospital^{11,29,42,49} and one in a nursing home for the elderly³¹) and one study focused on home care providers who were dispersed in a specific geographic location (Portland, Oregon).⁴⁴ Finally, one study enrolled administrative office workers employed at a Health Maintenance Organization.³⁶

Six studies enrolled workers from the manufacturing industry;^{12,25,28,33,38,39} all studies included multiple worksites (ranging from 3 to 26). Three described the potential occupational exposures associated with included worksites such as adhesives and abrasives,²⁵ chemicals and

textile dyes,³⁹ and lead.¹² Two studies described the extent of unionization across worksites; in one study, 5 of the 12 worksites randomized to the intervention were described as unionized³⁹ the other study included worksites that varied in terms of the extent of unionization (5 to 80 percent of workers were unionized across 5 sites).³⁸

Three studies enrolled workers from the construction industry. Two recruited workers from apprentice training programs^{10,48} affiliated with a labor union. One study recruited construction laborers who are members of the Laborer's international Union or North America who worked at various worksites across the US.³²

Five studies enrolled workers from various other industries including transportation and warehousing^{43,54}, agriculture,³⁰ and oil and gas extraction.⁴⁷ Finally, one study enrolled a population from various industries (and worksites) employed as municipal workers in one city (North Little Rock, Arkansas).³⁷

Occupational Groups

Studies set in the health care and social assistance industry primarily enrolled skilled nurses; some included a minority of other occupational groups, such as nursing aides, or other staff involved with patient care^{11,31,42,55} and one enrolled home care workers.⁴⁴ One study enrolled administrative office workers employed at a Health Maintenance Organization.³⁶

Across the six studies set in manufacturing worksites, three enrolled a majority of blue-collar production workers,^{28,33,39} two enrolled blue and white collar workers (but did not report specific details)^{25,38} and one did not describe the specific occupational groups (but focused on workers were exposed to lead.¹² In the three studies set in the construction industry, two recruited workers from apprentice training programs for various occupational groups, including iron workers^{10,48} boilermakers, bricklayers, ironworkers, and electricians, among others¹⁰ and one enrolled construction laborers (e.g., general laborers, concrete workers, demolition workers and others).³²

Studies set in other industries focused on a range of occupational groups, including truck drivers⁴⁵ postal workers,⁴³ farmers,³⁰ blue-collar production workers employed at an off-shore drilling site⁴⁷ and municipal workers in a variety of occupations.³⁷

Other Population Characteristics

In studies enrolling workers from the health care and social industry, populations were overwhelmingly female;^{11,29,31,36,44,49} in four studies, workers ranged from 35 and 47 years of age^{11,36,42,49} and one study enrolled home care workers with a mean age of 58 years.⁴⁴ In the six studies set in the manufacturing industry, the mean age of workers ranged from 30 and 50 years of age; in the four studies that reported the sex of workers, enrolled populations that were predominantly male.^{25,33,38,39} In the three studies focused on construction workers, populations were predominantly male and the average age of participants ranged from 28 to 41 years of age.^{10,32,48}

Few included studies described other demographic characteristics of populations such as race, ethnicity, education or income. In the nine studies describing the race of enrolled workers, a majority of workers were white; 2 of 9 studies enrolled populations that were made up of more than 25 percent non-white workers.^{32,44} In three studies that described the ethnicity of workers all included a minority of Hispanic workers ranging from 3 to 5 percent in two studies in a health care setting and 9 to 11 percent across study arms^{48,51} in one study that specifically enrolled in manufacturing worksites that employ multiethnic populations.³³

Baseline health status or comorbidity of included populations beyond specific factors related to the intervention (e.g., baseline body mass index or smoking status). One study enrolled home care workers with a high rate of depression (50 percent), anxiety (31 percent) and musculoskeletal complaints at baseline (>90 percent).⁴⁴ One study enrolling workers at a manufacturing site reported on the average number of comorbidities (mean=2) and overall general health status scores ranging from 66 to 67 of a maximum 100 (100=good health), indicating that the health of workers, overall and on average, was more favorable than not.³⁸

Interventions

Table 5 describes the characteristics of interventions evaluated across included studies, including the approach to integration and specific components or content of the intervention.

Table 5. Characteristics of Total Worker Health™ interventions

Author(s), Year Study Name		
Industry	Approach to Integration	Complexity Specific Content
Study Design (N Worksites; N Workers)		
Allen et al., 2003 ³⁸ International's Allergy Project Manufacturing NRCT (7; 519)	Organizational integration: Collaboration between OSH staff and on-site HP promotion staff to develop an intervention aimed at promoting safe medical treatment of allergies. Integrated Objective: Avoiding unnecessary sedating allergy medications may reduce work injuries, improve productivity and worker health.	Multicomponent Employee education about the appropriate medical treatment for allergies; message reinforced via newsletter, billboards, electronic alerts, and brochures); employees were provided with an on-site consultation with an allergist
Barbeau et al., 2006 ⁴⁸ MassBUILT Pilot Construction SG Pre-Post (1; 337)	Worker Participation: Integrated Objective: Smoking cessation intervention highlights the additive and synergistic effects of hazardous exposures and cigarette smoking.	Multicomponent Worksite tobacco cessation educational module taught by industrial hygienist highlighting synergistic effects of toxic exposures encountered by iron workers and cigarette smoking; included group motivational interviewing and behavioral counseling sessions; access to nicotine replacement therapy; workplace posters and newsletter articles that reinforced intervention messages related to smoking
Blackburn et al., 2009 ³⁰ Sustainable Farm Families Project Agriculture SG Pre-Post (NR; 128)	Integrated Objective only: Intervention promoted safe farm practices and focused on promoting healthy lifestyle behaviors.	Multicomponent Workshop series developed specifically for farmers focused on range of general health topics and activities (e.g., supermarket tour) including education/information promoting safe work practices; participants received manuals, a health risk assessment and medical referrals as needed

Table 5. Characteristics of Total Worker Health™ interventions (continued)

Author(s), Year Study Name		
Industry	Approach to Integration	Complexity Specific Content
Study Design Unit of Intervention (N Worksites; N Workers)		
Boggild and Jeppesen, 2001 ⁴²	Worker Participation:	Single component
Health care and social assistance	Integrated Objective: Investigators hypothesized that improvements in shift-work scheduling would reduce risk factors for heart disease (by facilitating healthy behavior, decreasing stress and improving sleep)	Improvements in shift work scheduling (promote more regular and predictable schedules, provide days off after night shifts, minimize weekend work, and rotate of day/evening and night shifts)
Cohort (7; 101)		
Caspi et al., 2013 ¹¹	Worker Participation:	Multicomponent
Health care and social assistance	Integrated Objective: Intervention aimed to reduce musculoskeletal disorders by simultaneously promoting safe patient handling and promoting physical activity	Workplace audit of the hospital unit safety features; development guidelines to improve co-worker collaboration in moving patients; posters and prompts in staff break rooms and computer stations to promote stretching and strength training breaks; monthly mentoring sessions were provided to workers focused on both safe patient handling and promoted physical activity (education and information on worksite fitness resources)
SG Pre-Post Worker (7; 374)		
Eriksen et al., 2002 ⁴³	Worker Participation:	Multicomponent
Transportation and warehousing	Integrated Objective: intervention focused on improving occupational hazards and promoting physical activity, stress reduction and health diet	Intervention included a worksite evaluation (conducted by investigators) to identify potential work hazards; training sessions focused on work-relevant exercise/training, participatory worker approach in developing ways to reducing work hazards; intervention components focused on stress reduction and promoting other health behavior (nutrition, physical activity)
RCT Worker (31; 860)		
Hodges et al., 2004 ³⁷	Organizational Integration:	Multicomponent
City of North Little Rock Employee Health and Wellness Program	Employee Participation: Advisory committee related to intervention design and implementation	Intervention aimed at providing increased access to primary health care services; health risks assessment and feedback; comprehensive employees health care services; HP programs and services related to OSH; employees also offered training sessions focused on stress, health, nutrition, physical activity
Varied	Integrated Objective: intervention focused on primary care, health promotion programs, and evaluation and treatment of work-related injuries for all employees	
SG Pre-Post (NR, 900)		

Table 5. Characteristics of Total Worker Health™ interventions (continued)

Author(s), Year Study Name		
Industry	Approach to Integration	Complexity Specific Content
Study Design Unit of Intervention (N Worksites; N Workers)		
Maes et al., 1998 ²⁸ Brabantia Project	Organizational Integration:	Multicomponent
Manufacturing	Worker Participation: In consultation with an advisory committee on design and intervention implementation	Formation of an advisory committee to guide organizational changes and improvements in ergonomic conditions (reorganization of production line to support organizational changes); onsite exercise facilities; lunchtime exercise sessions; smoking policy in cafeteria; healthy food and nutrition information in cafeteria; health fairs; health risk screenings and referrals to medical providers for “high-risk” factors
NRCT (3; 264)	Integrated Objective:	
Maniscalco et al., 1999 ⁴⁷	Organizational Integration	Multicomponent
Lafayette Offshore Business Unit Wellness Program	Worker Participation: Joint employee-management task force to develop intervention	An annual <i>Back Power</i> educational program included demonstrations of back assessment and exercises for preventing injury; safety training; train-the-trainer program for wellness crew representatives; on- and off-shore fitness facilities; group-based nutritional and smoking cessation program; annual subsidy for membership to local fitness facility; annual health assessment (including physical and fitness assessments) and personal review of health risk appraisal.
Mining, quarrying, and oil and gas extraction	Integrated Objective: Intervention aimed at reducing occupational injury and improving levels of physical activity	
SG Prep-Post Worker (1; 147)		
Nieuwenhuijse, 2004 ³⁶ Work Site Health Risk Project	Worker Participation Participatory approach to addressing OSH concerns	Multicomponent
Management of companies and enterprises	Integrated Objective: Intervention focused improving ergonomics and promoting healthy eating	Workshops focused on “at risk” (for injury/strain) body areas and included tips for using equipment correctly; posters, flyers, brochures, and email tips including a booklet entitled <i>The Twelve Golden tips for Office Workers</i> that promoted proper posture and preventive activities; assessments of work stations to identify and implement low-cost ergonomic solutions (e.g., keyboard or chair height)
SG Pre-Post Worker (1; 40)		
Okechukwu et al., 2009 ¹⁰ MassBUILT	Worker Participation Intervention developed based on worker input and union collaboration	Multicomponent
Construction	Integrated Objective: Smoking cessation intervention highlights the additive and synergistic effects of hazardous exposures and cigarette smoking	Tobacco cessation educational module highlighting synergistic effects of workplace exposures and cigarette smoking; posters displayed in worksites reinforced key concepts in the curriculum modules; eight weekly group behavioral counseling sessions offered covering a wide range of topics; nicotine replacement patches available free of charge to smokers; health profiles provided to workers as well as materials addressing how coworkers, friends and family members can support quit attempts
RCT Worksite (10; 1,817)		

Table 5. Characteristics of Total Worker Health™ interventions (continued)

Author(s), Year Study Name		
Industry	Approach to Integration	Complexity Specific Content
Study Design Unit of Intervention (N Worksites; N Workers)		
Olson et al., 2009 ⁴⁵ Wipfli et al., 2013 ⁴⁶ SHIFT Pilot Study Transportation and warehousing SG Pre-Post Worker (4; 29)	Integrated Objective: Intervention focused on weight loss and safe driving behaviors	Multicomponent Self-paced computer training on trucking safety, including information on work hazards; behavioral self-assessment; group weight loss goals in a competition (with other teams of workers); biweekly individual feedback on personal weight loss goals; self-paced computer training on exercise and diet; motivational interviewing phone sessions with a health coach
Olson et al., 2015 ⁴⁴ Community of Practice and Safety Support Health care and social assistance SG Pre-Post Worker (NR; 16)	Worker Participation Participatory approach to intervention Integrated Objective: intervention focused on injury prevention and health promotion	Multicomponent Monthly meetings focused on HP (healthy eating, functional fitness, mental health education, and body relaxation exercises) as well as OSH topics (back posture, back strain prevention, and use of tools and communication for hazard correction)
Palumbo et al., 2012 ²⁹ Health care and social assistance RCT Worker (1; 14)	Integrated Objective: Intervention aimed at improving both OSH and HP	Single component Tai Chi classes aimed at preventing reducing occupational hazards (musculoskeletal injuries, work-related stress) and promoting general health)
Porru et al., 1993 ¹² Manufacturing SG Pre-Post Worker (7; 50)	Integrated Objective: Coordinated strategies Intervention aimed at reducing work exposures and promoting general health	Multicomponent Worksite inspections of cleanliness, potential for harmful occupational exposures, and availability and use of exhaust ventilation and PPE; meetings with workers about lead toxicology and proper work safety practices as well as improving personal lifestyle behaviors that may minimize lead toxicity and improve general health
Sorensen et al., 1998 ³⁹ , Sorensen et al., 1996 ⁴⁰ , Sorensen et al., 1995 ⁴¹ WellWorks Manufacturing RCT Worksite (24; 2,386)	Organizational Integration Worker Participation: joint worker-management employee EABs Integrated Objective:	Multicomponent Worksite assessments by industrial hygienist (with recommendations to employers); update of company material safety data sheets; carbon monoxide testing; skill-building group classes regarding reducing occupational exposures; worker training on proper use of PPE; health fairs; collective risk assessment of nicotine levels and foods served in cafeterias; group sessions related to nutrition skills and other activities

Table 5. Characteristics of Total Worker Health™ interventions (continued)

Author(s), Year Study Name		
Industry	Approach to Integration	Complexity Specific Content
Study Design Unit of Intervention (N Worksites; N Workers)		
Sorensen et al., 2003; ²⁵ LaMontagne et al., 2005; ²⁶ Hunt et al., 2005 ²⁷ WellWorks-2	Organizational Integration Worker Participation: joint worker-management employee EABs Integrated Objective:	Multicomponent Worksite hazard assessment by industrial hygienist; group educational sessions; educational materials; demonstrations and displays; consultations with management on tobacco control policies, food catering, and cafeteria policies; messages concerning smoking or nutrition and the interplay with occupational exposures; demonstration and displays; self-assessment with feedback
Manufacturing RCT Worksite (15; 9,019)		
Sorensen et al., 2005; ³³ Hunt et al., 2007; ³⁴ Barbeau et al., 2004 ³⁵ Healthy Directions-Small Business	Organizational Integration Worker Participation joint worker-management employee EABs Integrated Objective: Intervention aimed at reducing occupational exposures and improving health behaviors	Multicomponent Worksite hazard assessment by industrial hygienist; table-top displays, demonstrations, and group discussions regarding occupational health; policies aimed at reducing hazardous occupational exposures; group discussions regarding physical activity, healthy eating, and smoking cessation; health fair; catering policies for inclusion of healthy food at company meetings and events; workers offered biometric and behavioral self-assessments with feedback and a smoking cessation program
Manufacturing RCT Worksite (26; 1,740)		
Sorensen et al., 2007 ³² Tools for Health	Worker Participation Intervention based worker input and union collaboration Integrated Objective: Intervention aimed at promoting healthy lifestyle and reducing occupational injuries	Multicomponent Baseline health survey with tailored feedback; one-on-one motivational interviewing focused on tobacco use and diet; provision of nicotine replacement therapy and counseling to participants interested in quitting tobacco; investigators created and mailed tip sheets that reinforced messages and addressed synergy between work hazards and health behavior
Construction RCT Worker (NR; 1,740)		
Tveito and Eriksen, 2009 ³¹ Health care and Social Assistance	Worker Participation In addressing OSH hazards Integrated Objective: Intervention aimed at reducing work injury and improving physical and mental health	Multicomponent Practical examination of the workplace to identify potential work hazards; workers provided input on ways to manage work stress; on-site aerobic dance classes provided as well as information sessions on stress, coping, health and lifestyle
RCT Worker (1; 40)		

Table 5. Characteristics of Total Worker Health™ interventions (continued)

Author(s), Year Study Name		
Industry	Approach to Integration	Complexity Specific content
Study Design Unit of Intervention (N Worksites; N Workers)		
Von Thiele Schwarz et al., 2015 ⁴⁹	Organizational Integration: integration of OSH and HP management into staff quality improvement meetings	Single component Integration of OSH and HP programs and functions into an ongoing employee participatory continuous improvement system; OSH and HP issues were addressed and recorded in meeting minutes along with other quality improvement issues
Health care and Social Assistance		
RCT Worksite (12; 312)		

EAB = Employee advisory board; GP = general practitioner; HP = health promotion; N = number (of participants or worksites); NR = not reported; NRCT = nonrandomized controlled trial; OSH = occupational safety and health; PPE = Personal protection equipment; RCT = randomized controlled trial; SG = single group.

Approach to Integration

We developed inclusion and exclusion criteria for study interventions (as discussed in the Methods). During data abstraction, we identified factors that have been highlighted as “indicators of integrated approaches” during data abstraction.⁹ Approaches to the integration of OSH and HP across included studies included the following: (1) organizational integration (e.g., strategic coordination across organizational departments responsible for OSH and HP), (2) worker participation in the development, design, planning and/or implementation of the intervention and (3) studies with an integrated objective or goal (with no specific organizational integration or worker participation); these studies were generally designed by investigators to specifically address OSH concerns and promote general health. Some included studies assessed interventions that used more than one approach to integration.

Organizational Integration

Eight included studies evaluated an intervention that involved strategic coordination across organizational departments (or staff) responsible for OSH and HP decision-making.^{25,28,33,37-39,47,49} Most focused on developing a comprehensive, program aimed at improving OSH and HP informed by staff from various departments (e.g., human resources, managers, OSH representatives, and HP representatives). One study assessed integration alone (with no additional OSH or HP content or components); OSH and HP programs were integrated into ongoing staff meetings (focused on quality improvement).⁴⁹

Worker Participation

Fifteen studies evaluated an intervention that involved worker participation in the development, design, planning, and/or implementation of the intervention.^{10,11,25,28,31-33,36,37,39,42,43,47,48} The type and degree of participation varied.

Six studies included worker participation in a committee with other organizational representatives (e.g., managers, human resource representatives, OSH and HP representatives) responsible for the design and implementation of the intervention.^{25,33,37,39,47} or in consultation

with a committee.²⁸ Three studies evaluated an intervention that was designed based on input (or prior research) from members of a specific occupational group (e.g., related to culture, potential occupational exposures, or work experience) and implemented in collaboration with union members or support from apprenticeship program leaders.^{10,32,48}

Six studies assessed an intervention that involved worker collaboration with study investigators (but not other organizational representatives) to give input or guidance on intervention implementation.^{11,42} Finally, four studies assessed interventions involving a participatory worker approach (with study investigators) to developing strategies to reduce occupational hazards (work stress and injuries)^{31, #1427} or developing ongoing workshops or meetings among groups of workers that addressed both OSH and HP (through educational topics and social support).^{11,36}

Organizational Integration and Worker Participation

Five studies involved an intervention that featured strategic coordination across organizational departments (or staff) responsible for OSH and HP decision-making and worker participation in the development, design, planning, and/or implementation of the intervention.^{25,28,33,37,39}

Integrated Objective Only

Four studies met inclusion criteria because they assessed an intervention that addressed both OSH and HP concerns designed by investigators based on the potential work hazards or risk factors for chronic disease in a specific occupational group.^{12,29,30,45} These studies did not explicitly describe whether the intervention was designed or implemented based on organizational integration or employee participation.

Intervention Complexity and Content

Most studies evaluated complex multi-component interventions “bundles” that included multiple components aimed at improving work safety and promoting healthy behavior (generally involving changes at the worksite as well as at the individual level).^{11,25-28,30-41,43-47} Three interventions involved a single component intervention specifically aimed at improving both OSH and HP.^{29,42,49}

The specific content across included interventions is heterogeneous. Only one study assessed the effectiveness of organizational integration alone (with no new added OSH or HP components).⁴⁹ Six studies focus primarily on providing a new HP initiative that was tailored to the potential work hazards of an occupational group or highlighted the potential synergistic effects of workplace exposures and health behavior.^{10,29,32,38,42,48} Three studies are focused primarily on reducing occupational injuries, illnesses or exposures and also include educational or other content that relates to personal health behavior.^{11,12,56} Eleven studies included interventions that introduced new comprehensive OSH and HP content or programs that was new (not previously available to workers before the intervention).^{28,30,31,37,43-45,47}

Interventions varied in terms of whether they were directed at the individual worker, worksite (or both). The majority of interventions included an educational component aimed at individual workers (e.g., workshops, educational materials, individual counseling). Five studies included a component aimed at the worksite level; six studies included changes in administrative controls or employer policies to improve (or remove) work hazards^{34,35,57} or recommendations from investigators (to employers) related to adopting proactive policies to reduce worker exposure to hazardous substances.^{25,39} Two studies included a component aimed at improving work

organization; one was aimed at improving manufacturing ergonomic conditions²⁸ and the other study assessed modifications to shift work schedules.⁴²

Incentives

Several studies included incentives to promote participation in the intervention. Some of the incentives for participating in interventions included health related items such as water bottles and stress relievers;^{28,37} raffles for cash^{10,45,46,48} or other^{28,45,46} prizes; contests;^{25-27,33-35} and payments for participation⁴⁴ or completion of the program.⁴⁷ In some studies,^{33-35,43} employers allowed workers to participate in intervention activities during their normal working hours.

Comparators

For a majority of studies,^{10,28,29,31,32,38-42,49} the concurrent control group received no intervention; the remaining studies (all RCTs) included active controls in the comparator group(s). Two studies had control groups that received one component of the integrated intervention,^{25,35} one of these included multiple comparators including one stress management training only, physical exercise intervention only, and one control group with no intervention.⁴³

Outcomes

Overall, studies included heterogeneous outcomes; few studies measured the same outcomes in similar populations of workers (Table 6). Of the 21 included studies, 10 measured a final health outcome; commonly evaluated included general physical health and mental health (often measured with the Medical Outcomes Study short form, 36 items [SF-36]), self-reported somatic complaints, and general stress. Nineteen studies measured an intermediate outcome; these included biomarkers associated with cardiovascular risk (cholesterol and glucose levels), rates of smoking cessation, and outcomes related to dietary habits.

Table 6. Outcomes evaluated in Total Worker Health™ interventions

Author(s), Year				
Study Name	Final Health Outcomes	Health Promotion: Intermediate Outcomes (Biometrics)	Health Promotion: Intermediate Outcomes (Behavior)	Occupational Safety and Health Outcomes
Industry				
Maniscalco et al., 1999 ⁴⁷	NR	Cholesterol	Diet Physical activity	Work related injuries First-aid cases
Lafayette Offshore Business Unit Wellness Program				
Mining, quarrying, and oil and gas extraction				
Nieuwenhuijse, 2004 ³⁶	Pain Functional ability	NR	Physical activity	Use of mini posture breaks Use of brief stretches
Work Site Health Risk Project				
Management of companies and enterprises				

Table 6. Outcomes evaluated in Total Worker Health™ interventions (continued)

Author(s), Year				
Study Name	Final Health Outcomes	Health Promotion: Intermediate Outcomes (Biometrics)	Health Promotion: Intermediate Outcomes (Behavior)	Occupational Safety and Health Outcomes
Industry				
Okechukwu et al., 2009 ¹⁰	NR	NR	Smoking	NR
MassBUILT				
Construction				
Olson et al., 2009, ⁴⁵ Wipfli et al., 2013 ⁴⁶	Overall health state	Body size Blood pressure Glucose Cholesterol Triglycerides	Diet (F&V) Physical activity Sleep, fatigue	Safe driving behaviors Compliance with regulations Organizational safety climate Supervisory safety climate
SHIFT Pilot Study				
Transportation and warehousing				
Olson et al., 2015 ⁴⁴	Depression Overall general health Overall mental health Musculoskeletal pain	Body size Blood pressure Cholesterol Triglycerides Glucose Strength and flexibility	Change in healthy behaviors Diet (F&V) Physical activity Sleep quality	Safety compliance Occurrence of safety actions Occupational fatigue Work stress
Community of Practice and Safety Support				
Health care and social assistance				
Palumbo et al., 2012 ²⁹	Overall general health Overall mental health Stress Musculoskeletal pain	Functional reach test Sit-and-reach test	NR	Nursing stress Work limitations including physical and mental demands Absenteeism
None				
Health care and social assistance				
Porru et al., 1993 ¹²	NR	Blood lead levels	Worker knowledge of lead-related diseases	Changes in worksite hygienic conditions Changes in work organization
None				
Manufacturing				

Few studies assessed outcomes related to OSH; measures of job-related stress, changes in risk of exposure to hazardous materials at work (including self-reported exposures), and changes in safety or ergonomic behaviors were most commonly reported.

No study evaluated rates of healthcare utilization (e.g., hospitalizations or emergency room visits). One study reported on rates of workers' compensation claims and short-term disability claims.³⁸

No study pre-specified harms of the intervention as outcomes to be evaluated. Two studies in the KQ 2 results, however, surveyed participants about potential adverse effects of the interventions.^{42,44}

Studies also evaluated a range of other outcomes that we did not include for KQ 2. Among them were the following: worker productivity and absenteeism, decision latitude (i.e., the ability to make work-related decisions), employee satisfaction with the intervention. Studies assessing absenteeism defined or measured absenteeism using different metrics or over various lengths of time.^{28,29,31,38,43,49} Three studies evaluated economic outcomes. One reported time lost costs,²⁹

one evaluated costs associated with treatment for occupational injuries and insurance rate increases,³⁷ and one calculated return on investment and net cost savings for all lost workday injuries and for only back injuries.⁴⁷

KQ 2. Effectiveness and Harms of Total Worker Health™ Interventions

Evidence for the effectiveness and harms of TWH interventions for improving outcomes consisted of nine RCTs, two NRCTs, and one prospective cohort study.^{10,25,28,29,31-33,38,39,42,43,49} We rated two RCTs as medium risk of bias^{32,33} and the other 10 studies as high risk of bias.

We rated studies as high risk of bias primarily because of a high risk of selection bias. Most studies had high overall attrition (ranging from 14 percent to 45 percent); many studies had differential attrition across study arms. In general, studies rated high risk of bias did not use any statistical methods to address missing data. Other common areas of bias included baseline differences between groups that the investigators did not address in their analyses.

The results of all studies synthesized for KQ 2 are described below by outcome category. We generally report results of studies rated medium risk of bias first (for each eligible outcome) and then results of studies rated high risk of bias. We also note the SOE grades (high, moderate, low, or insufficient) where relevant.

Key Points

- The 12 KQ 2 studies were heterogeneous; few studies of TWH interventions assessed the same outcomes among similar populations of workers. We found no evidence from studies rated low or medium risk of bias for many important health and safety outcomes of interest.
- TWH interventions were effective for improving rates of smoking cessation at 22-26 weeks compared with no intervention (low SOE).
- TWH interventions were effective for improving fruit and vegetable consumption at 26-104 weeks compared with no intervention (low SOE)
- Evidence was insufficient to assess the effectiveness of integrated interventions for improving levels of physical activity and decreasing consumption of red meat.

Health and Safety Outcomes

Quality of Life and Functional Status

No study rated as low or medium risk of bias assessed quality of life or functional status.

Two small RCTs (both high risk of bias) assessed improvements in quality of life among health care workers using the SF-36.^{29,31} One study compared a single component intervention (Tai Chi classes) aimed at improving reducing work injury and promoting general health among older (ages 49 and over) nurses.²⁹ The other study assessed a multicomponent intervention featuring employee participation in addressing OSH concerns and promoting healthy behavior (physical exercise and stress management).³¹ Both compared the integrated intervention to no intervention. Neither study found that the intervention significantly improved quality of life as measured by the SF-36 general health and mental health scores (Table 7). One study also reported multiple SF-36 subscores (physical functioning, role physical, bodily pain, vitality,

social functional, and role emotional). The intervention did not improve any of these subscores compared with no intervention.³¹

Table 7. Results of quality of life and functional status outcomes

Author, Year, Study Design	Arm (N) Outcome Timing (Weeks)	Quality of Life Outcomes	Functional Status Outcome
Palumbo et al., 2012 ²⁹ RCT	G1: Tai Chi (7) G2: No intervention (7) 15	SF-36 General Health Score Mean change from baseline (SD) G1: +0.6 (7) G2: -4.0 (4.2) p=0.33 SF-36 Mental Health Score Mean change from baseline (SD) G1: +2.5 (9.3) G2: -7.0 (9.1) p=0.62	WLQ, Mean Change From Baseline (SD) Overall score: G1: -3.1 (1.2) G2: -0.8 (1.4) p=0.03 Physical Demands Subscale: G1: -10.4 (11.7) G2: -2.5 (8.1) p=0.14 Mental Demands Subscale: G1: -11.1 (10.1) G2: 0 (6.6) p=0.03
Tveito and Eriksen, 2009 ³¹ RCT	G1: Integrated intervention (19) G2: No intervention (21) 36	SF-36 General Health Score Mean Score (95% CI) G1: Baseline: 42.3 (95% CI, 37.8 to 46.8) Post-test: 49.4 (95% CI, 43.5 to 55.3) G2: Baseline: 45.7 (95% CI, 41.7 to 49.7) Post-test: 44.7 (95% CI, 38.1 to 51.2) p=0.27 (difference between G1 and G2 post-tests) SF-36 Mental Health Score Mean Score (95% CI) G1: Baseline: 47.3 (95% CI, 42.7 to 51.9) Post-test: 52.9 (95% CI, 48.4 to 57.3) G2: Baseline: 45.7 (95% CI, 41.7 to 49.7) Post-test: 49.8 (95% CI, 45.9 to 53.7) p=0.98 (difference between G1 and G2 post-tests)	Not reported

CI = confidence interval; G = group; N = number of participants analyzed; RCT = randomized controlled trial; SD = standard deviation; SF-36 = Medical Outcomes Study Short Form (36 items); WLQ = Work Limitations Questionnaire.

The RCT evaluating a Tai Chi among nurses also assessed improvements in work-specific physical and psychological function measured by the Work Limitations Questionnaire (WLQ) (Table 7).²⁹ The WLQ measures the degree to which health problems interfere with ability to perform job roles, including the risk for musculoskeletal injuries.⁵⁸ At 15 weeks, nurses receiving

the intervention experienced an improvement in overall work limitations compared with nurses receiving no intervention.²⁹ The intervention was not associated with improvements in physical demands but was associated with improvements in mental demand, as measured by the two WLQ subscales.

Stress

No study rated as low or medium risk of bias assessed an intervention focused on stress.

Two studies (both high risk of bias) measured changes in levels of stress, one RCT²⁹ and one NRCT.²⁸ The Tai Chi intervention (described above) improved general and work-specific levels of psychological stress (Table 8).²⁹ General levels of psychological stress were assessed with the Perceived Stress Scale (PSS);⁵⁹ the intervention group did not experience lower PSS scores compared with the control group at 15 weeks.²⁹ Work-specific stress was assessed using the Nursing Stress Scale (NSS);⁶⁰ the intervention group did not reduce have weeks compared with the control group at 15 weeks.²⁹

Table 8. Results of general stress outcomes

Author, Year, Study Name Study Design Risk of Bias	Arm (N) Outcome Timing (Weeks)	Outcome Measure Mean Change From Baseline p-value
Maes et al., 1998 ²⁸	G1: Integrated Intervention (113)	Symptom Checklist-90
The Brabantia Project	G2: Control (113)	Mean change from baseline:
NRCT	156	G1: -0.01 G2: 0
High		p-value: NS
Palumbo et al., 2012 ²⁹	G1: Tai Chi (7)	General Stress:
RCT	G2: No intervention (7)	PSS, Mean change from baseline (SD)
High	15	G1: -2.8 (2.4)
		G2: -1.4 (3.9)
		p=0.42
		Work-specific Stress:
		NSS, Mean change from baseline (SD)
		G1: -6.1 (14.2)
		G2: -1.6 (2.4)
		p=0.89

G = group; N = number of workers; NRCT = non-randomized controlled trial; NS = not significant; PSS = Perceived Stress Scale; RCT = randomized controlled trial; SD = standard deviation.

The NRCT focused on workers from Dutch manufacturing worksites; worksites were assigned to a multicomponent intervention involving organizational integration and worker participation aimed at improving work conditions and HP to no intervention (Table 8).²⁸ General levels of stress were assessed with the Symptom Checklist-90 (SCL-90); at 3 years, levels of stress did not differ between workers employed at intervention sites and those at control sites.²⁸

Allergy Symptoms

No study rated as low or medium risk of bias assessed improvements in allergy symptoms.

One NRCT (high risk of bias) assessed a multicomponent intervention involving organizational integration between OSH and HP staff to promote appropriate use of allergy

medications (to reduce sedation at work and potential risk of injury) compared to no intervention.³⁸ Self-reported allergy severity did not improve in intervention worksites compared with control worksites at 28 weeks (change from baseline, intervention: range -1.2 to 2.8; control=-0.09; p= not significant per authors).³⁸

Subjective Health Complaints and Self-Rated Health

No study rated as low or medium risk of bias assessed subjective health complaints or self-rated health.

Two RCTs (both high risk of bias) assessed subjective health complaints using the Subjective Health Complaints (SHC) Inventory.^{31,43} The SHC Inventory assesses subjective health complaints across five subscales: musculoskeletal pain, pseudoneurology, gastrointestinal problems, allergy, and influenza.⁶¹ One RCT enrolled staff at a nursing home in Norway;³¹ the other enrolled Norwegian postal service workers.⁴³ Both evaluated a multicomponent intervention that included a worker participatory approach (to addressing OSH hazards) and comprehensive OSH and HP content (increasing physical exercise, stress management); one compared the intervention with no intervention³¹ and the other with physical activity alone, stress management alone, and a no intervention control group.⁴³ SHC subscales did not improve overall among workers receiving the integrated intervention compared with workers in a control group at 52 weeks in either study.^{31,43} However, in the postal workers trial, the intervention group reported fewer neck complaints than the control group (8 percent versus 48 percent, respectively; p=0.023) at 52 weeks; reports of complaints specific to the upper back or lower back did not differ between the intervention and control groups.³¹

One study (high risk of bias) compared organizational integration of OSH and HP functions alone with no integration. The study enrolled inpatient staff at Swedish hospital; responsibility for OSH and HP activities were incorporated into an ongoing quality improvement meeting.⁴⁹ The investigators assessed self-rated health using a single item; participants rated their current health status on a five-point scale (“very good” [1] to “very poor” [5]). Change from baseline in self-rated health did not differ between the integrated intervention and control groups at 52 or 104 weeks (p=0.72).⁴⁹

Intermediate Outcomes

Smoking Cessation

Four RCTs (three randomized by worksite) assessed rates of smoking cessation among manufacturing workers and construction workers;^{10,25,32,39} one cohort study assessed smoking cessation among Danish nurses⁴² (Table 9). One RCT was rated as medium risk of bias;³² the other studies were rated as high risk of bias. Although all studies relied on self-reported smoking, they used different measures (Table 9).

The medium risk of bias trial compared a multicomponent intervention designed in collaboration with with union representatives among construction laborers with no intervention (Table 9).³² Compared with the control group, more workers receiving the intervention reported 7-day abstinence at 26 weeks (for any tobacco use and for smoking), and also made more smoking quit attempts.

Table 9. Results of smoking-related outcomes

Author, Year, Study Name Study Design Risk of Bias	Arm (N) ^a Outcome Timing (Weeks) ^b	Measures of Smoking Cessation Mean Change From Baseline; p-value	Measures of Smoking Reduction or Quit Attempts
Okechukwu et al., 2009 ¹⁰	G1: Integrated Intervention (251)	% of baseline smokers reporting 7-day abstinence at 22 weeks: G1: 26%	Cut down by at least ½ pack smoked daily at 43 weeks: OR, 3.13 (95% CI, 1.55 to 6.31)
MassBUILT	G2: No intervention (239)	G2: 17% p=0.014	% of baseline smokers who made at least one quit attempt at 43 weeks: OR, 1.31 (95% CI, 0.88 to 1.96)
RCT High	22, 43	% of baseline smokers reporting 6-month abstinence at 43 weeks: G1: 9% G2: 7% p=0.48	% of workers reporting a decrease in the number of days smoked at 43 weeks: OR, 1.18 (95% CI, 0.62 to 2.25)
Sorensen et al., 1998 ³⁹⁻⁴¹	G1: Integrated Intervention (NR)	% of baseline smokers reporting 6-month abstinence:	Not reported
WellWorks	G2: No intervention (NR)	Overall sample: G1: 15% G2: 9% p=0.123	
RCT High	Overall N: 549 ^c 104	Subgroup of skilled and unskilled laborers (N=NR): G1: 17.9% G2: 9.0% p= NS Subgroup of office workers (N=NR): G1: 2.5% G2: 5.1% p=NS Subgroup of professionals and managers (N=NR): G1: 14.2% G2: 18.6% p= NS	
Sorensen et al., 2003 ²⁵⁻²⁷	G1: Integrated Intervention (436)	% of baseline smokers reporting 6-month abstinence:	Not reported
WellWorks-2	G2: Health promotion alone (389)	Overall sample: G1: 11.3% G2: 7.5% p=0.17	
RCT High	104	Subgroup of hourly workers (N=684): G1: 11.8% G2: 5.9% p=0.04 Subgroup of salaried workers (N=141): G1: 9.9 % G2: 12.7% p= 0.63	

Table 9. Results of smoking-related outcomes (continued)

Author, Year, Study Name Risk of Bias	Arm (N) Outcome Timing (Weeks)	Measures of Smoking Cessation Mean Change From Baseline; p-value	Measures of Tobacco Reduction or Quit Attempts Mean Change From Baseline; p-value
Sorensen et al., 2007 ³² Tools for Health RCT Medium	G1: Integrated Intervention (any tobacco use, N=134; smokers, N=101) G2: No intervention (any tobacco use, N=113; smokers, N=87) 26	% of baseline smokers reporting 7-day abstinence: G1: 19% G2: 8% p=0.03 % of baseline tobacco users reporting 7-day abstinence (any tobacco use): G1: 19% G2 7% p=0.005	% of baseline smokers who made at least 1 smoking quit attempt: G1: 53% G2: 35% p=0.03
Boggild and Jeppesen, 2001 ⁴² Cohort study High	G1: Improvements in shift work (26) G2: No intervention (60) 24	% of workers who smoked at baseline: G1: 27% G2: 27% Median change from baseline, (IQR): G1: 0 (0) G2: 0 (0) p= nonsignificant	Not reported

^a N here is for the subgroup of smokers (unless otherwise stated).

^b Unless otherwise specified, this is the timing of outcome assessment in relationship to the baseline survey. This is the timing of outcome measurement in regards to the baseline survey.

^c This was the number of smokers who responded to baseline and follow-up assessments; the study reports that in the cohort of participants who responded to both baseline and follow-up assessments, 23% were smokers.

G = group; IQR = interquartile range; N = number of participants analyzed; NR= not reported; NS= not significant (p-value not reported by authors); OR = odds ratio; RCT = randomized controlled trial.

Three RCTs assessing multicomponent interventions involving organizational integration and employee participation were rated high risk of bias, two enrolled primarily manufacturing workers and one enrolled building trade apprentice training program participants. One RCT compared an integrated intervention with a HP only intervention, the overall rate of 6-month abstinence did not differ between intervention and control groups at 2 years.²⁵ However, in a subgroup of hourly workers, a significantly greater number of workers in the intervention worksites reported 6-month abstinence than those employed at control worksites.²⁵ In another RCT comparing an integrated intervention with no intervention, 6-month abstinence rates did not differ significantly between the intervention and control worksites at 2 years.³⁹ In a subgroup analysis based on job type, more skilled and unskilled workers at intervention sites reported 6-month abstinence than skilled and unskilled workers at control sites ; conversely, other groups of workers (office workers, professionals and managers) had slightly higher 6-month abstinence rates than control sites than those employed at intervention sites. The results of these subgroup analyses were not statistically significant.³⁹ Finally, the RCT of training program participants found reduced 7-day abstinence at intervention worksites compared with control sites at 22 weeks; however, 6-month abstinence rates did not differ significantly between groups at 43 weeks.¹⁰

The cohort study of Danish inpatient nurses found that improving shift work scheduling was not associated with lower rates of smoking over 24 weeks.⁴²

Alcohol Consumption

No included studies rated medium or low risk of bias assessed changes in alcohol consumption.

The cohort study of Danish nurses (high risk of bias) described above assessed the effect of improving shift work scheduling on alcohol intake. The median alcohol consumption per week did not differ between the intervention and control groups at 24 weeks (median change from baseline =0 in both groups; p=not significant per authors).⁴²

Healthy Eating

Four RCTs (all from the same research team) measured outcomes related to healthy eating behaviors among US manufacturing and construction workers (Table 10); two RCTs were rated medium risk of bias^{32,33} and two high risk of bias.^{25,39}

Table 10. Results of healthy eating outcomes

Author, Year, Study Name Study Design Risk of Bias	Arm (N) Outcome Timing (Weeks)	Consumption of Fruit and Vegetable Servings per day, p-value	Other Health Eating Results; Mean Change From Baseline p-value
Sorensen et al., 1998 ³⁹⁻⁴¹	G1: Integrated Intervention (NR)	Servings per day, mean change from baseline: G1: 0.22	Daily fiber intake (grams per 1000 kcal), mean change from baseline:
Wellworks RCT	G2: No intervention (NR)	G2: 0.09 p=0.04	Overall: G1: 0.58 G2: 3.39 p=0.08
High	Overall N=2386		
	104		Subgroup of skilled and unskilled laborers: G1: 0.89 G2: 0.36 p=0.012
			Subgroup of office workers: G1: 0.11 G2: 0.29 p=NS
			Subgroup of professionals and managers: G1: 0.47 G2: 0.57 p= NS
			Number of kcal consumed as fat, % change from baseline: G1: -3.36 G2: -1.55 p=0.01

Table 10. Results of healthy eating outcomes (continued)

Author, Year, Study Name Study Design Risk of Bias	Arm (N) Outcome Timing (Weeks)	Consumption of Fruit and Vegetable Servings per day, p-value	Other Health Eating Results; Mean Change From Baseline p-value
Sorensen et al., 2003 ²⁵⁻²⁷	G1: Integrated Intervention (2,413)	Servings per day, mean change from baseline: G1: - 0.10	NR
WellWorks-2 RCT	G2: Health promotion alone (2,214)	G2: +0.05 p=0.24	
High	104		
Sorensen et al., 2005 ³³⁻³⁵	G1: Integrated Intervention (NR)	% of participants consuming 5 or more servings of fruits and vegetables per day, mean change from baseline:	% of participants consuming 3 or fewer servings of red meat per week, mean change from baseline:
Healthy Directions-Small Business Study RCT	G2: No intervention (NR)	Overall: G1: +5.4% G2: +1.7% p=0.41	G1: +4.1% G2: +3.0% p=0.72
Medium	78 ^b	Managers: G1: -5.5% G2: +3.6% p=0.048 Workers: G1: +7.5% G2: +1.1% p=0.048	
Sorensen et al., 2007 ³²	G1: Integrated Intervention (298)	Servings per day, mean change from baseline: G1: +1.52 (SD=3.89)	NR
Tools for Health RCT	G2: No intervention (280)	G2: -0.09 (SD=3.31) p= <0.0001	
Medium	26		

^a Per the authors, 974 workers responded to both the baseline and follow-up survey. This “embedded cohort” is included in the overall analysis but results are not reported separately for this group.

^b 18 months

G = group; kcal = kilocalorie; N = number of participants analyzed; NR = not reported; NS = not significant; RCT = randomized controlled trial; SD = standard deviation.

The RCTs rated medium risk of bias assessed a multicomponent intervention aimed at improving health eating and reducing work exposures; one enrolled manufacturing workers and also included organizational integration and employee participation in the implementation of the intervention³³ the other enrolled unionized construction workers and aimed to promote healthy behavior and raise awareness about safe work practice via phone calls and literature.³² The trial involving construction workers found an increased consumption of fruit and vegetables among workers employed at intervention sites compared with controls at 26 weeks³² while the study in manufacturing workers found no difference in fruit and vegetable consumption in the overall sample of workers. However, in a subgroup analysis based on job type, hourly workers at intervention worksites increased consumption while managers decreased consumption of fruit and vegetables.³³ In addition, the change from baseline in red meat consumption did not differ between groups in the overall sample at 26 weeks.³³

Two RCTs (both high risk of bias) enrolled primarily manufacturing workers;^{25,39} both assessed multicomponent interventions that included employee and management participation in the design and implementation of the intervention. One trial compared the integrated intervention with to an HP-only intervention;²⁵ fruit and vegetable consumption did not change for the intervention and control groups over 104 weeks.²⁵ The other trial compared an integrated intervention with no intervention over 104 weeks; workers at intervention sites increased intake of fruit and vegetables, and decreased intake of red meat compared with workers at control sites.³⁹ Workers at intervention and control sites did not differ in the change from baseline fiber intake. However, in a subgroup analysis based on job type, skilled and unskilled laborers at intervention sites increased fiber consumption more than laborers at control sites; there was no significant difference for other groups of workers (office workers, professionals and managers).³⁹

Physical Activity

One RCT (medium risk of bias) assessed the change in exercise frequency at 78 weeks.³³ The study enrolled workers employed at manufacturing worksites and assessed a multicomponent intervention that included organizational integration, employee participation as well comprehensive OSH and HP components. The mean change from baseline in the percentage of employees who exercised 2.5 hours or more per week did not differ between intervention and control worksites (Table 11).

Table 11. Results of physical activity outcomes

Author, Year, Study Name Risk of Bias	Arm (N) Outcome Timing (Weeks)	Change in Physical Activity Level
Sorensen et al., 2005 ³³⁻³⁵	G1: Integrated intervention (NR)	Change from baseline in the percentage of participants who exercise ≥ 2.5 hours per week:
	G2: No intervention (NR)	
Healthy Directions-Small Business Study RCT	Overall N=3092 ^a	Overall: G1: +5.4 G2: -0.9% p=0.23
Medium	78	Managers: G1: -2.0 G2: +3.7 p= 0.09 Workers: G1: +7.1 G2: -2.1 p= 0.09
Boggild and Jeppesen, 2001 ⁴²	G1: Improvements in shift work (26)	No exercise at baseline (%): G1: 12% G2: 7%
Cohort study	G2: No intervention (60)	
High	24	Median change from baseline (IQR): G1: 0 (1) G2: 0 (0) p=NS

^a Per the authors, 974 workers responded to both the baseline and follow-up survey. This “embedded cohort” is included in the overall analysis but results are not reported separately for this group.

G = group; IQR = interquartile range; N = number of participants analyzed; NS = nonsignificant; RCT = randomized controlled trial.

The cohort study of Danish nurses (high risk of bias) assessed the effect of improving shift work scheduling (e.g., increased shift regularity) on outcomes associated with cardiovascular disease risk over 24 weeks.⁴² The mean change from baseline in the percentages of workers who reported not exercising did not differ between the intervention and control groups (Table 11).

Cholesterol

No included study rated low or medium risk of bias measured changes in cholesterol levels. The Danish nurses' cohort study assessed the effect of improving shift work scheduling on cholesterol levels over 24 weeks.⁴² Workers in the intervention group had significantly lower low density lipoprotein (median change from baseline, mmol/L: -0.2 versus 0.1; $p=0.001$) and total cholesterol levels (median change from baseline, mmol/L= -0.1 versus 0.0; $p=0.003$) than workers in the control group; the groups did not differ in high density lipoprotein levels (mean change from baseline, mmol/L = 0.1 versus -0.1; $p=0.18$).⁴²

Cardiovascular Disease Risk Scores

No included study rated low or medium risk of bias assessed changes in a cardiovascular disease (CVD) risk score.

One NRCT (high risk of bias) of Dutch manufacturing workers assigned worksites to a multicomponent intervention involving strategic organizational integration and employee participation aimed at improving work conditions and promoting health or no intervention.²⁸ At 1 year, the intervention group experienced a small but statistically significant decrease in CVD risk score compared with the control group (change from baseline, intervention: -0.002 versus control: 0.007; $p=0.01$); the difference was not sustained at 2 years. At 2 years, both groups experienced a small overall increase in CVD risk from baseline (intervention= 0.008 versus control= 0.01); the between-group difference is small and the authors did not report a measure of variance for this observation.²⁸

Hazardous Work Exposures

No included study rated low or medium risk of bias measured hazardous work exposures.

Two RCTs (high risk of bias) reported on outcomes related to hazardous work exposures. Both studies enrolled manufacturing workers and involved employee participation in the design and implementation of the intervention components. One trial assessed self-reported exposures to carcinogenic substances after the intervention;³⁹⁻⁴¹ the intervention and control sites did not differ in reported hazardous exposures (quantitative data were not provided). The other trial involved pre- and post-intervention worksite assessments conducted by an industrial hygienist;²⁵ potential exposure to hazardous processes was assessed with a nonvalidated rating scheme. The investigators reported no differential loss of higher hazard processes between intervention and control worksites and found no statistically significant differences for any specific work conditions between intervention and control sites.

Utilization Outcomes and Occupational Injury and Illness Surveillance Outcomes

Workers Compensation and Short-term Disability

No included study rated low or medium risk of bias assessed rates of health care utilization or occupational injury and illness surveillance outcomes.

One NRCT (high risk of bias) enrolled workers at US automotive manufacturing worksites.³⁸ Worksites were assigned to a multicomponent intervention developed through collaboration between OSH and HP programs to promote appropriate medical treatment for allergies (to improve personal health, work safety, and worker productivity) or to no intervention. The study measured rates of workers' compensation (WC) claims and short-term disability claims via the employer's disability database. The percentages of participants at who had one or more WC claims and short-term disability claims at 28 weeks did not differ between intervention and control sites (p-value not significant per authors for both outcomes).

Harms

No included study rated low or medium risk of bias reported on harms associated with an intervention.

Two studies (both high risk of bias) reported potential harms; in both cases, harms were not prespecified. The Danish nurses cohort study of shift work scheduling surveyed participants in the intervention group about potential adverse effects of the intervention.⁴² The intervention group judged the new schedule as having had a worse impact on family life (compared with the pre-intervention schedule) at 52 weeks.⁴² The authors did not report quantitative results (e.g., measure of variance or p-value for the difference between groups); in addition, whether the effect of shift work on family life was measured in the comparison group was unclear. One trial of Norwegian postal workers assessed potential harms of a 4-arm study that compared an integrated intervention with aerobic exercise alone, stress management alone, and no intervention.⁴³ The authors asked participants whether the interventions had any influence on "health, work environment, work situation, physical fitness, muscle pain, ability to deal with stress and knowledge of how to maintain good health," which they reported as a 3-category scale (better, unchanged, worse). They reported no subjective negative effects of the intervention at either 12 or 52 weeks after the intervention (but did not present any quantitative results).⁴³

KQ 3. Characteristics of Effective Integrated Interventions

KQ 3 describes characteristics of effective integrated interventions; it is intended to provide information about the interventions that show benefit for improving worker health for employers that may want to implement an evidence-based integrated intervention and for researchers who want to evaluate integrated interventions. We limited this question to those interventions effective for improving any outcome eligible for KQ 2 for which we found at least low strength of evidence (SOE) for benefit. Due to heterogeneity across included studies (in terms of populations, interventions, outcomes), and methodological limitations we were only able to make SOE conclusions for two outcomes: rates of smoking cessation (measured by 7-day abstinence rates) over 22 to 26 weeks and increased fruit and vegetable consumption over 26 to 104 weeks. The results for these outcomes are discussed in KQ 2 and SOE assessments are shown in Appendix D. Overall, the applicability of these conclusions is very limited; these conclusions are based on four studies enrolling apply primarily to US blue-collar manufacturing and construction workers.^{10,32,33,39}

To address this question, we focused on describing characteristics of interventions that relate to two main domains. The first addressed the *approach to integration*, or the way in which the intervention simultaneously addresses OSH and HP elements. The second focused on the *specific content of the intervention*, i.e., (a) OSH components (e.g., administrative controls to improve or

remove work hazards or individual education related to work hazards) and (b) HP components (e.g., environmental changes or individual education to promote healthy behavior).

Key Points

- Effective interventions informed by worker participation in the development, design, planning, or implementation of the intervention (or in more than one of these steps).
- All effective interventions included comprehensive program content that highlighted the potential additive or synergistic risks of hazardous workplace exposures and health behavior.
- Effective interventions tailored intervention components or materials to cultural or social aspects of the worker population (e.g., to workers with low literacy skills or workers for whom English was not their first language).
- All effective interventions are multicomponent, complex interventions that reinforce messages about behavior change through multiple levels of influence or multiple modes of delivery (or both) over time.

Detailed Synthesis

Approach to Integration

In all four studies contributing to our SOE grades, interventions were informed by worker participation in the development, design, planning, or implementation of the intervention. Two studies set in manufacturing worksites^{33,39} involved the creation of a joint-worker-management employee advisory board (EAB) comprised of workers, production managers, and representatives from health and safety and human resources departments that planned and implemented the intervention in partnership with the study investigators. EAB members gave input on specific components; for example, policies aimed at reducing hazardous occupational exposure were co-written by the study investigators and workplace managers. Production managers included in planning activities helped to ensure that workers could alter their work schedules to participate in intervention activities.³³ In two studies, the intervention that was designed based on input (or prior research) from members of the targeted occupational group (e.g., related to culture, potential occupational exposures, or work experience) and implemented in collaboration with union members or support from apprenticeship program leaders.^{10,32}

In all four studies, interventions were designed to simultaneously address OSH and HP concerns by highlighting the potential additive or synergistic risks of hazardous workplace exposures and health behavior, either through interventions delivered at the worksite (manufacturing worksites)^{10,33,39} or via telephone-based interviewing and counseling combined with written educational materials provided to individual construction workers.³² In addition, all four studies tailored intervention components to cultural or social aspects of the worker population (aside from the specific work-related hazards); for example, designing written materials so that they were accessible to workers with low literacy skills³³ and ensuring that surveys and other written materials were available in multiple languages for workers whose first language was not English^{32,33} or developing curricula that resonated with the workers' occupational culture.¹⁰

Given the limited number of studies contributing to our SOE grades (4) and the heterogeneity of interventions, we had insufficient detail across all interventions to determine whether certain

strategies of integration directly contributed to the efficacy of an intervention or whether certain strategies are more or less effective for certain outcomes or subgroups of workers.

Complexity and Content of Interventions

All four interventions were multicomponent, complex interventions that reinforced messages about behavior change through multiple levels of influence or multiple modes of delivery (or both) over time. For example, three studies conducted at a manufacturing worksite created multiple opportunities for workers to participate in worksite based activities at the individual level (e.g., behavioral self-assessments with feedback, interaction with table-top displays and demonstrations).^{10,33} One also included intervention components aimed at modifying the work environment to improve worker health and safety (e.g., adoption of new catering policies that promoted healthy eating and inclusion of an industrial hygiene assessment and feedback to worksites aimed at improving worker safety).³³ In one study focused on construction workers, one-to-one motivational interviewing counseling sessions (via telephone) were conducted over time; a mailed report with individual feedback and written educational materials was provided at baseline and were periodically reinforced by sending “tip sheets” during the intervention.³² Both studies included an individual health assessment (survey) with tailored feedback based on responses.^{32,33}

All interventions included HP or OSH components (or both) that were new and not previously available to workers. Two studies primarily provided HP content that highlighted OSH concerns^{10,32} and two offered comprehensive HP and OSH components at the worksite.^{33,39}

We did not find any direct evidence to determine whether specific components add substantial benefit. That is, no study rated as medium or low risk of bias directly compared the delivery of an intervention having a specific component with the same intervention but lacking that specific component. Separating out individual characteristics from the overall intervention “bundle” that was effective was not possible.

KQ 4. Contextual Factors

KQ 4 asks “What contextual factors have been identified as potential modifiers of effectiveness in studies of integrated interventions?” Such factors can be quite diverse: (a) the legal-regulatory environment (e.g., state laws with respect to union representation); (b) employer characteristics, policies, or benefits (e.g., availability of health insurance coverage or paid sick leave); (c) work organization (e.g., shift work); and (d) social or economic factors (e.g., income or availability of community resources to support or promote health).

To address this question, we abstracted relevant data from all 21 included studies when investigators reported them. We included factors that were noted in the articles’ results (e.g., whether the intervention was more or less effective at worksites that differed by a specific contextual factor) and also issues that investigators may have discussed that could have potentially modified the effectiveness of interventions.

Key Points

- Few studies identified contextual factors that could have played a role in modifying the effectiveness of interventions.
- Work organization factors and union membership status were the two most commonly mentioned contextual factors. Other factors noted by at least one study included the

following: presence of another (concurrent) intervention implemented during the study period, health insurance status (of the workers), and company downsizing.

Detailed Synthesis

Of the 21 studies in this review, 7 addressed contextual factors. Table 12 summarizes relevant contextual factors for specific occupational groups, settings, and key health and safety. These factors varied by study population and work setting. In general, they related to the following:

Table 12. Characteristics of studies describing contextual factors

Author(s), Year Study Name	Source Population Country	Outcomes	Contextual factors
Study Design Unit of Intervention (N worksites; N workers)			
Allen et al., 2003 ³⁸ International's Allergy Project NRCT Worksite (7; 519)	Heavy manufacturer of medium- and heavy-duty trucks and diesel engines United States	Allergy symptoms; medication adherence; productivity; absenteeism; rates of workers' compensation claims and short- term disability claims	Health insurance status Union membership (including contract negotiations)
Barbeau et al., 2006 ⁴⁸ MassBUILT Pilot SG Pre-Post Worker (1; 337)	Iron worker apprentices United States	Smoking	Union membership
Boggild and Jeppesen, 2001 ⁴² Cohort Worker (7; 101)	Nurses and nursing aides Denmark	Cholesterol level, exercise, smoking, alcohol, shift work schedule	Staffing levels; Human resource policies related to overtime
Eriksen et al., 2002 ⁴³ RCT Worker (31; 860)	Post office or postal terminal workers Norway	Subjective health complaints; physical activity; sick leave; job stress	Company downsizing
Olson et al., 2009 ⁴⁵ , Wipfli, 2013 ⁴⁶ SHIFT Pilot Study SG Pre-Post Worker (4; 29)	Truck drivers United States	Multiple general health outcomes, including BMI, blood pressure, cholesterol, glucose level, diet and physical activity; safe driving behaviors; Workplace safety climate	Work organization factors; Other concurrent worksite OSH interventions
Porru et al., 1993 ¹² SG Pre-Post Worker (7; 50)	Small factories, including bronze and brass foundries, lead shot production facilities, and pylon painting factory Italy	Blood lead level; worker knowledge of lead-related diseases; changes in worksite hygienic conditions; changes in work organization	Other concurrent HP or OSH interventions
Sorensen et al., 1998 ³⁹⁻⁴¹ WellWorks RCT Worksite (24; 2,386)	Manufacturers of industrial, chemical, and other products; textile dyeing; firefighting; and newspapers United States	Smoking; consumption of fruits and vegetables; workplace hazard exposures	Union membership

BMI = body mass index; HP = health promotion; N = number; NRCT = nonrandomized controlled trial; OSH = occupational safety and health; RCT = randomized controlled trials; SG = single group.

- Health insurance status and access to primary care services,
- Work organization factors,
- Company downsizing,
- Union membership status, including ongoing union contract negotiations, and
- Other ongoing OSH interventions.

Access to health care was identified as a potential modifier of an intervention aimed at improving the appropriate treatment of allergies among manufacturing workers (improving symptoms and reducing use of sedating medications).³⁸ The authors noted that 13 percent of participants were enrolled in a health maintenance organization but did not document the health insurance status of other participants. According to the investigators, the overall low participation rate in the intervention was perhaps related to the fact that a change from a sedating to a nonsedating allergy medication required a physician's office visit and a prescription (and potentially a copayment for both); at the time of the study, nonsedating allergy medication had not become available over the counter.³⁸ Primary care physicians were not involved in the intervention strategy; the authors speculated that coordination with prescribing health care providers might have improved participation and modified the effectiveness of the intervention.³⁸

Work organization factors were also noted as potential modifiers of intervention effectiveness.^{42,45} In the study to improve shift work schedules in a Danish hospital, staff shortages and changes in overtime policies during the intervention period affected participation in the study.⁴² A new policy for handling of overtime work among nurses was put into effect during the intervention period; before the new agreement, overtime work was not paid, but the new policy provided paid overtime. The authors observed that this policy change reduced work hours for nurses (and meant extra work for the existing staff); it also led to more scheduling changes than expected (unrelated to the goals of the intervention).⁴² A study of teams of truck drivers noted that work schedules may have limited participation and effectiveness of the intervention.⁴⁴ The authors noted that isolation among drivers and changes in driving routes during the intervention may have led to low levels of communication within teams, which then may have limited the effectiveness of the intervention.⁴⁴

Company downsizing during the intervention was identified as a potential moderating factor in a multi-site study of Norwegian postal workers.⁴³ The workers were told during the intervention that the number of post offices would be reduced considerably (from 2,300 to 1,400). One focus of the integrated intervention was on stress management and improving subjective health complaints; the authors speculated that company downsizing may have introduced turmoil and instability in the workplace.⁴³

Union membership was considered to be a moderating factor in three studies enrolling US manufacturing workers.^{38,39,48} In one study, union concentration varied significantly by worksite; the authors noted that contract renewal negotiations were ongoing (at the time of the study) and may have affected responses to surveys among people with chronic health conditions.³⁸ In another study, five of 12 worksites were unionized; union representatives served on EABs responsible for the intervention planning and implementation at worksites randomized to the integrated intervention.³⁹ This practice may have led to differences in participation and intervention effectiveness across worksites. Finally, support of the intervention by apprenticeship program leaders may have played a role in successful intervention implementation.⁴⁸ However, the authors noted that apprentice program leaders granted the study team 1 hour for the "toxics and tobacco" curriculum module instead of the requested 5 hours because of a concern that replacing instructions on other important health and safety issues would endanger the apprentices.

on the job. The authors did not comment on whether the shortened curriculum might have affected rates of smoking cessation at intervention sites.⁴⁸ Of note, studies enrolling manufacturing workers in non-US countries did not mention union membership as a potential contextual factor, probably because the level of unionization is high in these populations and because industrial labor relations in those countries is more firmly established than in similarly unionized sectors in US setting.^{12,28}

One study enrolling truck drivers identified another concurrent OSH policy change as a potential modifiers of effectiveness.⁵¹ One company implemented a mechanical speed-governing intervention for some trucks near the onset of the main study intervention; reduction in overspeed (driving over a preset speed criterion) may have been partially attributable to the effects of speed governing (and not the integrated intervention).⁵¹ Of note, only one study described a formal process of monitoring for other OSH interventions or work organization changes that could potentially affect the measurement of outcomes; the authors of this study checked for changes in policies related to OSH periodically during the intervention before assessing outcomes related to the intervention at various outcome timings but did not identify any.¹²

KQ 5. Evidence Gaps

In this KQ we describe important research gaps identified in the conduct of this review. We consider “research gap” to mean a topic area for which missing or inadequate information limited our ability to reach a conclusion on the effectiveness of TWH interventions. We outline research gaps below by work settings and populations, interventions, comparators, and deficiencies in methods (including issues that related to the design and reporting of studies). We consider work settings and populations together since most studies recruit workers from specific worksites and who are at risk of similar work-related illnesses and injuries (and potentially similar in terms of demographics or risk factors for chronic diseases). The evidence gaps outlined here are those we considered most relevant to work settings and populations in the United States.

Work Settings and Populations Studied

Geographic Setting

Included studies enrolled focused on worksites in select geographic areas. Our SOE grades primarily apply to blue-collar workers in the Northeast region of the United States (Massachusetts). No studies enrolled workers from states in the Southwest and only one study each was conducted in a Southeastern or Western state (Arkansas and Oregon, respectively). Only one study enrolled a population across different states (construction workers affiliated with the Laborers’ International Union of North America (LIUNA)).³²

Industries and Occupational Groups

Our SOE grades primarily apply to blue-collar workers employed in the manufacturing and construction industries. In many cases, studies only reported on the characteristics of the industry or worksite from which populations was recruited and did not always describe the range of occupations of enrolled workers. We noted the following gaps that relate to the industry or occupational groups included in studies of TWH interventions:

- No studies enrolled workers from industries in these industry sectors: wholesale and retail trade; utilities (electricity, water, gas); information (publishing, broadcasting, telecommunications, etc.); finance and insurance; real estate; professional, scientific and technical services; educational services; arts, entertainment, and recreation; or accommodation and food services.
- The service sector as a whole (e.g., retail, transportation, communications industries, healthcare) is under-represented in included studies when considering the prevalence of work-related injuries among workers in this sector. According to the United States Bureau of Labor Statistics (BLS), the service sector accounted for 65.5 percent of all private industry occupational illness cases in 2012 (the most recent data available)⁶² However, a majority of included studies enrolled workers from goods-producing industries which accounted for 34.3 percent of the cases all private industry occupational illness cases in 2012.⁶²
- Only two included studies enrolled workers from the transportation and warehousing industry^{43,45} No included study enrolled air, rail, water, or ground transit transportation workers. Healthcare was represented but studies primarily focused on select occupational groups (e.g., registered nurses).
- Few studies enrolled workers from the natural resources and mining sector (one in agriculture³⁰ and one in off-shore oil drilling⁴⁷). No studies enrolled workers in forestry and logging; fishing and hunting; or the on-shore mining industries (coal, metal and nonmetal).
- In terms of specific occupational groups, only three studies enrolled office and administrative support workers (the occupational group with the largest employment in the United States). The following occupations were not represented in included studies: sales and related occupations (the second-largest major occupation group in the United States);⁶³ food preparation and serving workers (the third-largest major occupation group in the United States)⁶³ and workers in education and training are a large occupation group not represented in the studies.

Populations and Subgroups Studied

The demographics of workers enrolled in included studies were often not well described (aside from factors specific to the work setting or potential work hazards). We noted the following gaps that relate to major demographic features and baseline health of workers enrolled in included trials:

- No study enrolled populations of workers who were very young or very old; (the mean age of workers enrolled across included studies ranged from 30 to 50 years). According to the BLS, workers aged 45 to 54 had the highest number of days-away-from-work cases in 2013 and workers 65 and over had a greater number of median days away from work compared to younger workers.⁶⁴
- Women were underrepresented in industries other than those typically conducted in a health care setting. According to the BLS, injuries and illnesses to men accounted for only 61 percent of all nonfatal injury and illness cases in 2013.⁶⁴
- No study addressed differences in outcomes among subgroups of workers defined by age, sex, race, ethnicity, comorbidity, or income.
- People who work part-time (regardless of their occupation) were often excluded from studies.

Interventions

Studies evaluated quite diverse interventions; the type and level of integration involved in interventions varied substantially. The TWH model envisions the “strategic and operational coordination of policies, programs, and practices designed to simultaneously prevent work-related injuries and illnesses, and enhance overall workforce health and well-being.”⁹ Included studies did not use standard language regarding the nature or extent of integration; we found no direct evidence on whether certain strategies of integration are more or less effective than others. Sorensen and colleagues identified a core set of indicators of the implementation of integrated approaches to OSH and HP to help facilitate what is meant by “integrated strategies.”^{9,35} These indicators were often not well described across included studies. We identified the following gaps that relate to TWH interventions:

- A minority of included studies (eight studies) evaluated an intervention that clearly involved organizational integration; that is, multiple departments within the work setting were involved with planning, implementing, and managing the intervention (e.g., OSH department, HP programs, and sometimes others).
- We found no studies that directly assessed whether specific combinations (or specific types) of program content were more or less effective than other combinations. Studies differed in terms of the degree to which program content focused on OSH concerns versus HP concerns.
- We could not assess whether strategies were more or less effective based on their complexity (single versus multi-component) or level of influence (e.g., environmental or administrative controls, individual worker education, or both). Most studies assessed complex heterogeneous interventions that targeted both the worker and worksite. Few studies assessed single-component interventions aimed at improving the work environment or work structure with the associated goals of improving OSH and promoting personal health.

Comparators

In general, studies were not designed to assess directly the effectiveness of integration alone (compared with no integration). Most studies compared an intervention that addressed both OSH and HP with no intervention. The effects of the new HP or OSH component (or both) offered to the intervention group could not be separated from the effects of integration.

Among studies that compared an intervention to no intervention (or usual workplace programs), studies generally did not describe the HP or OSH programs already in place and available to workers.

Outcomes

Although we considered a wide-range of outcomes for this review, we were only able to rate the evidence for two: smoking cessation and changes in fruit and vegetable consumption. We identified the following gaps in terms of the outcomes measured in included studies:

- We were not able to assess the strength of evidence related to any OSH outcome (e.g., rates of occupational injuries or illnesses). Very few studies measured outcomes important to OSH. Whether integrated interventions improve workplace safety (compared with OSH programs or policies that are not integrated with HP) is unclear.

- We did not find many of the outcomes listed in our inclusion criteria for KQ 2 (effectiveness and harms of interventions) reported in included studies, including the following: incidence of injuries, cardiovascular disease, or cancer; morbidity related to injuries, illnesses, or chronic disease (including work-related injuries and illnesses); depression or anxiety; BMI; and measures of healthcare utilization (hospitalizations, emergency department visits, or outpatient clinic visits).
- Very few studies (all rated high risk of bias) reported on the following outcomes: validated measures of quality of life or functional status; stress (job or general stress); rates of workers' compensation claims, short-term disability claims, alcohol use and illicit drug use.
- No included studies prespecified harms as an outcome of interest. We looked for evidence on the following potential harms of interventions but did not find any: increased barriers to reporting work-related injuries or illnesses, work stress, adverse effects on personal health, discrimination, victim-blaming.

Deficiencies in Methods

Of the 21 included studies, 12 had a pre-post design; because of the inherent risk of bias in pre-post studies, we did not include them in our assessment of the benefits and harms of TWH interventions. Among the 12 included studies eligible for KQ 2 (i.e., those with a concurrent control group), many had methodological limitations including the following:

- Among RCTs, we found inadequate reporting of randomization and allocation concealment. Most RCTs randomized at the worksite level; the number of worksites randomized was often small. In one case, two worksites were reported to be “randomized” and we called this a non-randomized controlled trial.²⁸
- Studies often did not adequately describe the flow of participants; particularly those that randomized or assigned interventions at the worksite level. Most studies measured outcomes based on survey responses before and after an intervention; Response rates to the baseline surveys among eligible workers were sometimes low or not reported, and this practice contributed to selection bias.
- Overall attrition was high in several studies (14 to 54 percent in studies rated high risk of bias). Some studies did not provide sufficient data to calculate differential attrition between study arms. For the 10 studies that had very high overall attrition (>20 percent), high differential attrition (>15 percent), or both; only one employed methods to address missing data⁴³ (e.g., last observation carried forward). Most trials did nothing to address missing data (i.e., analyzed only completers).
- Statistical analyses did not often address important baseline differences between intervention and control groups; in some cases, important demographic information was not provided in order to assess whether there were baseline differences between groups.
- Several studies had small sample sizes and thus lacked power for determining intended effects.
- Investigators sometimes did not provide information on their statistical methods; also, authors sometimes did not provide measures of variance (e.g., confidence intervals) for outcomes. This limited our ability to assess the precision of outcomes across studies.

- In several studies, contamination of the control arms compromised internal validity; for example, due to another worksite policy or program initiated during the intervention period that could have influenced outcomes measured in the study.
- In some cases, the length of follow-up may not have been adequate to assess the stability of findings over time. Only six studies measured outcomes at or beyond 1 year. Our SOE grades (based on 4 studies) relate to outcome timings over 22 to 104 weeks.

KQ 6. Future Research Needs

In this chapter, we make specific recommendations for future research focused on TWH interventions. These suggestions are based only on our evidence synthesis and are the research gaps outlined in KQ 5. These suggestions are intended to inform the Pathways to Prevention Workshop¹⁹ on TWH; the workshop panel will consider these research needs in order to develop a summary of the current state of the science and future research needs related to TWH interventions.

Below we make specific recommendations following the PICOTS framework laid out in KQ 5. We recommended specific research designs for the most important evidence gaps that relate to works setting and populations, interventions, comparators, outcomes and study designs and deficiencies in methods.

Work Settings and Populations Studied

Geographic Setting

- Including a broader range of workers in future studies could increase the applicability of TWH interventions.
- Future research could target specific worksites in diverse regions of the United States that differ in terms of state government policy on economic development and labor, which can influence where employers locate and the attention they give to worker safety. There is geographic variation across the United States in terms of fatal occupational injury rates (higher in the Western and Southern regions, in rural areas, and in less wealthy states).⁶⁵ Similarly, states in the South and Midwest also have higher rates of risk factors for chronic disease, such as smoking, compared with other regions.⁶⁶ Targeted regions of the country with a high burden of both occupational injuries and illnesses and chronic diseases should be a priority.

Industries and Occupational groups

- The applicability of interventions that were effective for reducing smoking and improving fruit and vegetable consumption is limited. Most included studies were published more than 10 years ago; current practice in terms of the availability of HP smoking programs (at the worksite and via the healthcare setting) is likely to have improved over time. Future studies should consider similar interventions in other groups of workers (e.g., other blue-collar workers) or different types of manufacturing sites to help clarify (1) the strength of evidence for these interventions and (2) the applicability across various work settings and populations.
- Future studies should consider focusing on populations of workers in the service sector, such as retail, transportation, communications industries, and healthcare given the high

burden of occupational injuries in these populations. Occupational groups representing the largest number of US workers should also be a focus of future research (office and administrative support workers, sales and related occupations, and food preparation and serving workers) since these groups represent a large portion of the US workforce.

- Future studies could enroll workers from a range of work settings (who receive a similar intervention, for example) in order to understand what factors related to the work setting modify the benefits (and potential harms) of TWH interventions. This approach might include recruiting worksites that differ by size, ownership of the enterprise (e.g., whether private or public sector), work organization (e.g., full- versus part-time job patterns), and unionization.

Populations and Subgroups Studied

- NIOSH lists issues related to aging in the workforce and younger workers as subjects of interest to TWH;⁶⁷ future studies should consider targeting these populations in order to assess whether integrated interventions are effective in improving health and safety outcomes that are unique to younger and older groups of workers.
- Future studies could assess whether there are differences in outcomes among subgroups of workers defined by occupation, age, sex, race, ethnicity, comorbidity, or income (when appropriate). It is not clear whether certain categories of workers would benefit more from TWH compared with others. Workers with more resources (e.g., comprehensive health care insurance, access to wellness programs, sufficient income to afford gym memberships, etc.) may have less interest in TWH interventions. Identifying categories of workers for whom TWH is most effective, and under what conditions, should be a priority for future research.
- Future studies could enroll populations who are likely to have specific concerns related to work-life balance (e.g., caregivers of young children or elderly parents, single parents). Issues specific to work-family balance are noted by NIOSH subjects of interest to TWH but have not been specifically addressed in the included studies.⁶⁷

Interventions

- Future studies should clearly describe the approach used to integrate OSH and HP programs, policies, or goals. Investigators should lay out a framework for how the integrated intervention addressed *both* OSH and HP goals. Authors of future studies might refer to research that has outlined indicators and metrics for “integration” and describe which of these integrated metrics were accomplished by the intervention under study.⁹
- The interventions we identified as effective suggest that employee participation is an important element in TWH interventions. Future studies should determine the most effective form of worker participation. It is unclear, for example, how the involvement of union representatives compares with “rank-and-file” worker participation in planning committees.
- Studies should focus on interventions targeted at work environment or work structure. Work schedules (e.g., shift work, work hours), for example, have been highlighted as an issue relevant to TWH. Few studies have assessed whether specific integrated strategies that modify the work environment (coordinated across OSH and HP departments and

informed by worker participation, for example) improve worker health more than those focusing primarily on providing education or behavioral counseling to individual workers.

- Traditionally, OSH interventions focus on activities defined by a “hierarchy of control,” in which identified hazards are controlled through elimination (physically removing the hazard), substitution (replacing the hazard), engineering controls (isolating people from the hazard), administrative controls (changing the way people work), or personal protective equipment (PPE).⁶⁸ Studies of integrated interventions should describe how the integration of HP fits into this framework, and describe clearly where the synergy lies in terms of improvements in worker health.

Comparators

- An established body of literature supports the efficacy of worksite wellness interventions on smoking and other important outcomes.⁶⁹ Future studies should try to assess directly the effectiveness of integration itself; in other words, this aspect of TWH interventions should be isolated from the effects of a new or improved OSH or HP component. Studies should directly compare an integrated approach with a program that has similar OSH and HP elements available but does not deliberately coordinate them.
- In addition, investigators should clearly describe what OSH and HP programs already in place and available to workers outside of the intervention being evaluated.

Outcomes

- Future studies should consider the feasibility of measuring OSH outcomes. To understand whether “integration” improves both OSH and HP, researchers need to examine indicators of improved safety.
- Future studies should also consider direct measures of worker health if possible; for example, using validated measures of health status, functional status and wellness. Researchers should measure the incidence or morbidity associated with chronic diseases when feasible, particularly in populations of workers at higher risk of chronic conditions (e.g., older workers).
- Research teams should also choose intermediate outcomes carefully. These outcomes should be based on strong evidence for linkages to final health outcomes and for relevance to a particular population of workers. For example, rates of smoking might be prioritized in some populations because it is strongly associated to OSH and HP concerns due to (1) a high prevalence of smoking among a particular group of workers (2) potential synergistic adverse effect related to a specific job hazard and (3) a strong connection to cardiovascular disease risk (regardless of factors related to OSH). Intermediate outcomes that have an unclear relationship to final health outcomes or OSH outcomes should receive less focus; this might include, for example, measures of cholesterol in otherwise healthy populations of workers who are young and have a low prevalence of other cardiovascular disease risk factors.
- Future studies should consider assessing harms or potential unintended consequences of interventions – at the individual worker and organizational level. For example, studies could assess whether there was a concern about not giving adequate time or resources to OSH programs in studies of integrated interventions (among managers or OSH

personnel). At the individual worker level, potential harms might vary by work setting or occupation; these might include increased barriers to reporting work-related injuries or illnesses or work stress.

Deficiencies in Methods

Future studies could address methodological limitations related to TWH interventions by considering the following:

- Worksite randomized trials should follow the recommendations for reporting outlined in the Consolidated Standards of Reporting Trials (CONSORT) statement extension to cluster randomized trials⁷⁰ or the Ottawa Statement on the ethical design and conduct of cluster randomized trials.⁷¹ In particular, authors should provide a clear flow diagram to show the flow of participants from group assignments through the final analysis.
- Authors should consider whether the sample size (of worksites and workers) is likely to be sufficient to show a difference for the outcome being studied.
- RCTs are not always feasible due to barriers associated with studying populations of workers. Well-designed prospective cohort studies (or non-randomized trials) with a concurrent control group would inform the strength of evidence related to TWH interventions. Studies without a control group are unlikely to contribute significantly to an understanding of the strength of evidence supporting TWH interventions (because of the inherent bias in the design); these designs should be avoided.
- For outcome measures by surveys, authors should describe the demographics (including occupational groups) of workers who respond and do not respond to surveys when feasible so that this can be taken into consideration when assessing the potential risk of selection bias in studies.
- Authors should plan for high attrition (and differential attrition) and use methods to address missing data when necessary, approaches such as imputation of missing data should be considered, based on the potential reasons for missing data and the outcomes under study.
- Studies should address baseline differences between groups (when they are present) using appropriate statistical methods.
- Studies should report confidence intervals (or other measures of variance) for all outcomes they evaluate so that the precision around outcome measures is clear.
- Finally, in reporting their studies, authors should highlight whether other (concurrent) OSH and HP policies or programs had been in place or implemented during the intervention in question; this will enable them to assess bias associated with contamination.

Discussion

Key Findings and Strength of Evidence

For this report, we conducted a systematic review to evaluate the evidence for Total Worker Health™ (TWH) interventions. The purpose of this review is to provide an evidence report that the Pathways to Prevention Workshop Program of the Office of Disease Prevention at the National Institutes of Health (NIH) can use to inform a workshop focused on TWH.¹⁹ Below, we summarize the main findings by each Key Questions (KQ), including giving the strength of evidence (SOE) for the bodies of evidence pertaining to the effectiveness and harms of interventions (KQ 2). We then discuss the findings in relation to what is already known, applicability of the findings, implications for decisionmaking, limitations of the review process or evidence base, and conclusions.

We had 21 studies described in 28 publications. We summarized the work settings and populations, interventions, and outcomes of all included trials in KQ 1. Of these 21 studies, 12 had a concurrent control group and were also eligible for KQ 2 (which assessed the effectiveness and harms of TWH interventions).^{10,25,28,29,31-33,38,39,42,43,49} We rated the risk of bias as high for 10 of these studies; the remaining two studies were medium risk of bias.

We graded SOE only for outcomes reported in at least one study rated as medium risk of bias. When we graded evidence as insufficient, the evidence was unavailable, did not permit estimation of an effect, or did not permit us to draw a conclusion with at least a low level of confidence. An insufficient grade does not indicate that an intervention has been proven to lack effectiveness.

For KQ 3, we describe the characteristics of intervention for which we found at least low SOE for benefit. For KQ 4, we examined all 21 studies to determine whether authors noted important contextual factors that might have affected intervention effectiveness and to inform our assessment of the gaps in the literature (KQ 5) and future research needs (KQ 6) related to TWH interventions.

Key Question 1. Characteristics of Studies Evaluating Total Worker Health™ Interventions

Work Setting and Populations

Across all 21 studies, the heterogeneity was substantial with respect to the work settings, populations, intervention, and outcomes evaluated. Studies enrolled populations employed primarily in manufacturing, construction, or health care work settings. Workers in the manufacturing industry were more commonly male (blue-collar production workers and white-collar workers) whereas workers from the health care and social assistance industry were overwhelmingly female (nurses). Commonly targeted workers were between 30 and 50 years of age; only one study evaluated a younger workforce (mean <30 years of age), and only one study evaluated an older workforce (mean >50 years of age).

Few studies described the baseline health status or medical comorbidity of included populations. The health promotion (HP) or occupational safety and health (OSH) services available at worksites (in addition to the intervention under study) were generally not described.

Interventions and Comparators

All studies assessed an intervention focused on an integrated objective (in terms of addressing both OSH and HP). Eight interventions involved strategic integration across organizational departments responsible for OSH and HP and fifteen involved worker participation in the development, design, planning, and/or implementation of the intervention. Five studies assessed an intervention with both strategic integration and worker participation. Most studies were multicomponent interventions; only four evaluated a single component intervention. Only one included study assessed the effectiveness of integration alone (without added OSH or HP content). Eleven studies assessed interventions that included new, comprehensive HP and OSH components not previously available to workers; six included mostly HP content (tailored to the specific needs of workers) and three studies assessed interventions that focused primarily on addressing OSH but also included components aimed at HP. Of the 21 studies, 12 included concurrent control groups, most of which received no intervention. Four studies included active control groups that received a HP component only.

Outcomes

Overall, these studies measured a wide variety of outcomes. Few studies assessed the same outcomes in similar populations of workers. Approximately half of studies measured a final health outcome (e.g., quality of life, functional status). Few studies evaluated work-related injuries or illness; work stress was the most commonly outcome related to OSH. The most commonly reported intermediate health outcomes were body mass index (BMI), biomarkers associated with risk of cardiovascular disease (e.g., cholesterol), and health behaviors (primarily physical activity, smoking, and dietary behaviors). Several studies assessed outcomes that we did not include in KQ 2 (effectiveness and harms of TWH integrations); the two most common were measures of absenteeism and economic evaluation outcomes.

Key Question 2. Effectiveness and Harms of Interventions

Evidence for the effectiveness and harms of TWH interventions for improving outcomes consisted of nine randomized controlled trials (RCTs), two nonrandomized controlled trials (NRCTs), and one prospective cohort study.^{10,25,28,29,31-33,38,39,42,43,49} Few studies of TWH interventions assessed the same outcomes among similar populations of workers.

We rated two RCTs as medium risk of bias^{32,33} and the other 10 studies as high risk of bias. We rated studies as high risk of bias primarily because of a high risk of selection bias. Most studies had high overall attrition (ranging from 14 percent to 45 percent); many studies had differential attrition across study arms. In general, studies rated high risk of bias did not use any statistical methods to address missing data. Other common areas of bias included baseline differences between groups that the investigators did not address in their analyses.

The 12 KQ 2 studies were quite diverse; few studies of TWH interventions assessed the same outcomes among similar populations of workers. We found no evidence from studies rated low or medium risk of bias for many important health and safety outcomes of interest. Table 13 summarizes our key findings by outcomes. We found low SOE to support the effectiveness of TWH interventions for improving rates of smoking cessation over 22-26 weeks and increasing the consumption of fruit and vegetable intake over 26 to 104 weeks compared with no intervention. Evidence was insufficient to permit us to assess the effectiveness of integrated interventions for improving levels of physical activity or decreasing the intake of red meat.

Table 13. Summary of key findings and strength of evidence for Total Worker Health™ interventions

Population, Intervention and Comparator Time-point	N Studies; N Subjects Study Limitations	Outcome and Results	Strength of Evidence
Construction laborers ³² and manufacturing workers ¹⁰ Integrated Intervention versus no intervention; 22-26 weeks	2; 737 Medium or High	<p>One RCT rated medium ROB:³² % of baseline smokers reporting 7-day abstinence (smoking) at 26 weeks: G1: 19% G2: 8% p=0.03</p> <p>% of baseline tobacco users reporting 7-day abstinence (any tobacco use) at 26 weeks: G1: 19% G2: 7% p=0.005</p> <p>One RCT rated high ROB:¹⁰ % of baseline smokers reporting 7-day abstinence at 22 weeks: G1: 26% G2: 17% p=0.014</p>	Low for benefit
Manufacturing workers ^{25,33} and construction workers ³² Integrated Intervention versus no intervention; 26-104 weeks	3; 6056 Medium or High	<p>Two RCTs rated medium ROB: Servings per day, mean change from baseline:³² G1: +1.52 (SD=3.89) G2: -0.09 (SD=3.31) p= <0.0001</p> <p>% of participants consuming 5 or more servings of fruits and vegetables per day, mean change from baseline:³³</p> <p>Overall: G1: +5.4% G2: +1.7% p=0.41</p> <p>Managers: G1: -5.5% G2: +3.6% p=0.048</p> <p>Workers: G1: +7.5% G2: +1.1% p=0.048</p> <p>One RCT rated high ROB:³⁹ Servings per day, mean change from baseline: Servings per day, mean change from baseline: G1: 0.22 G2: 0.09 p=0.04</p>	Low for benefit

Table 13. Summary of key findings and strength of evidence for Total Worker Health™ interventions (continued)

Population, Intervention and Comparator Time-point	N Studies; N Subjects Study Limitations	Outcome and Results	Strength of Evidence
Manufacturing workers; ³³ Integrated Intervention versus no intervention; 78 weeks	1; 3092 Medium	% of participants consuming 3 or fewer servings of red meat per week, mean change from baseline: G1: +4.1% G2: + 3.0% P=0.72	Insufficient
Manufacturing workers; ³³ Integrated Intervention versus no intervention; 78 weeks	1; 3092 Medium	Change from baseline in the percentage of participants who exercise ≥ 2.5 hours per week: Overall: G1: +5.4 G2: -0.9% p=0.23 Managers: G1: -2.0 G2: +3.7 p= 0.09 Workers: G1: +7.1 G2: -2.1 p= 0.09	Insufficient

G = group; N = number; RCT = randomized controlled trial; ROB = risk of bias; SD = standard deviation.

Key Question 3. Components of Effective Interventions

We evaluated common characteristics of interventions that were effective for improving any outcome eligible for KQ 2 for which the SOE for benefit was at least low. Overall, we were no able to make very few SOE conclusions due to limitations of the evidence base and heterogeneity across studies; four studies, primarily enrolling blue-collar manufacturing and construction workers, contributed to our SOE grades for smoking cessation and healthy eating outcomes. We focused on characteristics of interventions that relate to the approach to integration and specific content of the intervention.

Effective interventions were informed by worker participation—in the development, design, planning, or implementation of the intervention (or in more than one of these steps). All effective interventions included comprehensive program content that highlighted the potential additive or synergistic risks of hazardous workplace exposures and health behavior. Effective interventions tailored intervention components or materials to cultural or social aspects of the worker population (e.g., to workers with low literacy skills, workers for whom English is not their first language). All effective interventions are multicomponent, complex interventions that reinforce messages about behavior change through multiple modes of delivery over time.

Key Question 4. Contextual Factors

We abstracted data from included studies that related to contextual factors that the original authors had identified as potential modifiers of intervention effectiveness. We included factors that had been noted in the results (e.g., whether the intervention was more or less effective at

worksites that differed by a specific contextual factor) and also those mentioned in the discussion that could have potentially modified the effectiveness of interventions.

Seven studies identified a contextual factor that could have played a role in modifying the effectiveness of interventions. Work organization factors and union membership status were the two commonly mentioned contextual factors. Other factors mentioned in at least one study included the following: presence of another (concurrent) OSH or HP policy implemented during the study period; health insurance status or access to primary care services; and employee stress or strain related to company downsizing during the intervention period.

Key Question 5. Research Gaps

We found numerous gaps in the literature base supporting TWH interventions in terms of work settings and populations, interventions, comparators, and deficiencies in methods.

Work Settings and Populations

No studies enrolled workers from states in the Southwest; only one study each was conducted in a Southeastern or Western state (Arkansas and Oregon, respectively). Only one US study enrolled a population across different US regions.³²

No studies enrolled workers from industries in these sectors: wholesale and retail trade; utilities (electricity, water, gas); information (publishing, broadcasting, telecommunications); finance and insurance; real estate; professional, scientific and technical services; educational services; arts, entertainment, and recreation; or accommodation and food services. The service sector as a whole (e.g., retail, transportation, communications industries, health care) is underrepresented in included studies when considering the prevalence of work-related injuries among workers employed in this sector. In terms of specific occupational groups, only three studies enrolled office and administrative support workers (the occupational group with the largest employment in the United States).⁶³ The following occupations were not represented in included studies: sales and related occupations (the second-largest major occupation group in the United States);⁶³ food preparation and serving workers (the third-largest major occupation group in the United States).⁶³ Finally, workers in education and training represent a large occupation group that was not represented in the studies we reviewed.

No study enrolled populations of workers who were very young or very old. Women were underrepresented in industries other than those typically conducted in a health care setting. No study addressed differences in outcomes among subgroups of workers defined by age, sex, race, ethnicity, comorbidity, or income. People who work part-time (regardless of their occupation) were often excluded from studies.

Interventions

Studies evaluated quite diverse interventions; the type and level of integration involved in interventions varied substantially. We found no direct evidence on whether certain strategies of integration are more or less effective than others. A minority of included studies (eight studies) evaluated an intervention that clearly involved a systems-level approach to integration; that is, multiple departments within the work setting were involved with planning, implementing, and managing the intervention (e.g., OSH department, HP programs, and sometimes others). In some cases, the degree of coordination across departments was unclear (even though the intervention addressed both OSH and HP concerns).

We found no studies that directly assessed whether specific combinations (or specific types) of program content were more or less effective than other combinations. Studies differed in terms of the degree to which program content focused on OSH concerns versus HP concerns.

We could not assess whether strategies were more or less effective based on their complexity (single versus multi-component) or level of influence (e.g., engineering or administrative controls, individual worker education, or both). Most studies assessed complex heterogeneous interventions that targeted both the worker and worksite. Few studies assessed single-component interventions aimed at improving the work environment or work structure with the associated goals of improving OSH and promoting personal health.

Comparators

In general, studies were not designed to assess directly the effectiveness of integration alone (compared with no integration). Most studies compared an intervention that addressed both OSH and HP with no intervention. The effects of the new HP or OSH component (or both) offered to the intervention group could not be separated from the effects of integration. Studies that compared an intervention with no intervention (or usual workplace programs) generally did not describe the HP or OSH programs already in place and available to workers.

Outcomes

Although we considered a wide range of outcomes for this review, we were able to rate the evidence for only two: smoking cessation and changes in fruit and vegetable consumption. Very few studies measured outcomes important to OSH. Whether integrated interventions improve workplace safety (compared with OSH programs or policies that are not integrated with HP) is unclear.

We found no eligible studies eligible for KQ 2 (effectiveness and harms of interventions) reporting on the following outcomes: incidence of injuries, cardiovascular disease, or cancer; morbidity related to injuries, illnesses, or chronic disease (including work-related injuries and illnesses); depression or anxiety; BMI; and measures of health care utilization (hospitalizations, emergency department visits, or outpatient clinic visits). A few studies (all rated high risk of bias) reported on the following outcomes: validated measures of quality of life or functional status; stress (job or general stress); rates of workers' compensation claims, short-term disability claims, alcohol use and illicit drug use.

No included studies prespecified harms as an outcome of interest. We looked for evidence on the following potential harms of interventions but did not find any: increased barriers to reporting work-related injuries or illnesses, work stress, adverse effects on personal health, discrimination, or victim-blaming.

Deficiencies in Methods

Of the 21 included studies, 12 had a pre-post design; because of the inherent risk of bias in pre-post studies, we did not include them in our assessment of the benefits and harms of TWH interventions. Among the 12 studies eligible for KQ 2 (i.e., those with a concurrent control group), many had methodological limitations. Among RCTs, we found inadequate reporting of randomization and allocation concealment. Most RCTs did their randomization at the worksite level; the number of worksites randomized was sometimes small. Studies often did not adequately describe the flow of participants; this was particularly true of those that randomized or assigned interventions at the worksite level.

Most studies measured outcomes based on survey responses before and after an intervention. Response rates to the baseline surveys among eligible workers were sometimes low or not reported, and this practice contributed to selection bias.

Overall attrition was high in several studies (14 percent to 54 percent in studies rated high risk of bias). Most studies did not conduct an intention to treat analysis (i.e., they analyzed only completers). We encountered baseline differences between groups in several studies; statistical analyses did not often address these differences. Several studies had small sample sizes and thus lacked power for determining intended effects.

Investigators sometimes did not provide information on their statistical methods; also, authors sometimes did not provide measures of variance (e.g., confidence intervals) for outcomes. In several studies, contamination of the control arms compromised internal validity; for example, another worksite policy or program initiated during the intervention period could have influenced outcomes measured in the study.

Finally, in some cases, the length of followup may not have been adequate to assess the stability of findings over time. Only six studies measured outcomes at or beyond 1 year.

Key Question 6. Future Research Needs

Work Settings and Populations

Including a broader range of workers in future studies could increase the applicability of TWH interventions. Future research could target specific worksites in diverse regions of the United States that differ in terms of state government policy on economic development and labor; these factors can influence where employers locate and the attention they give to worker safety.

The applicability of interventions that were effective for reducing smoking and improving fruit and vegetable consumption is limited. Future studies should consider similar interventions in other groups of workers (e.g., other blue-collar workers) or different types of manufacturing sites to help clarify (1) the strength of evidence for these interventions and (2) the applicability across various work settings and populations.

Consideration should be given to a broader set of populations of workers in the service sector, such as retail, transportation, communications industries, and health care in future TWH interventions. These populations have a high burden of occupational injuries. Occupational groups representing the largest number of US workers should also be a focus of future research; these include (but might not be limited to) office and administrative support workers, sales and related occupations, and food preparation and serving workers. Future studies could enroll workers from diverse work settings (who receive a similar intervention, for example) to assess which factors related to the work setting modify the benefits (and potential harms) of TWH interventions. This approach might include recruiting worksites that differ by size, ownership of the enterprise (e.g., whether private or public sector), work organization (e.g., full- versus part-time job patterns), and unionization.

Future studies could assess whether there are differences in outcomes among subgroups of workers defined by occupation, age, sex, race, ethnicity, comorbidity, or income (when appropriate). It is not clear whether certain categories of workers would benefit more from TWH compared with others. Future studies could enroll populations who are likely to have specific concerns related to work-life balance (e.g., caregivers of young children or elderly parents, single

parents) or workers with unique health and safety concerns (older workers or those who are very young).

Interventions

Future studies should clearly describe the approach used to integrate OSH and HP programs, policies, or goals. Investigators should lay out a framework for how the integrated intervention addressed *both* OSH and HP goals. Studies should focus on interventions targeted at work environment or work structure. Work schedules (e.g., shift work, work hours), for example, have been highlighted as an issue relevant to TWH. Few studies have assessed whether specific integrated strategies that modify the work environment (coordinated across OSH and HP departments, for example) improve worker health more than those focusing primarily on providing education or behavioral counseling to individual workers.

Comparators

An established body of literature supports the efficacy of worksite wellness interventions on smoking and other important outcomes.⁶⁹ Future studies should try to assess directly the effectiveness of integration itself; in other words, this aspect of TWH interventions should be isolated from the effects of a new or improved OSH or HP component. Studies should directly compare an integrated approach with a program that has similar OSH and HP elements available but does not deliberately coordinate them. In addition, investigators should clearly describe what OSH and HP programs already in place and available to workers outside of the intervention being evaluated.

Outcomes

Future studies should consider the feasibility of measuring OSH outcomes. To understand whether “integration” improves both OSH and HP, researchers need to examine indicators of improved safety.

Future studies should also consider direct measures of worker health if possible; for example, using validated measures of health status, functional status and wellness. Researchers should measure the incidence or morbidity associated with chronic diseases when feasible, particularly in populations of workers at higher risk of chronic conditions (e.g., older workers).

Research teams should also choose intermediate outcomes carefully. These outcomes should be based on strong evidence for linkages to final health outcomes and for relevance to a particular population of workers.

Finally, future studies should consider assessing harms or potential unintended consequences of the interventions. Measures of harms and unanticipated effects should be made at both the individual worker and the organizational level.

Deficiencies in Methods

Worksite randomized trials should follow the recommendations for reporting outlined in the Consolidated Standards of Reporting Trials (CONSORT) statement extension to cluster randomized trials⁷⁰ or the Ottawa Statement on the ethical design and conduct of cluster randomized trials.⁷¹ In particular, authors should provide a clear flow diagram to show the flow of participants from group assignments through the final analysis. Of the 21 studies we included in this review, 12 had a pre-post design; because of the inherent risk of bias in pre-post studies,

we did not include them in our assessment of the benefits and harms of TWH interventions. Among the 12 studies eligible for KQ 2 (i.e., those with a concurrent control group), many had methodological limitations

Randomized trials are not always feasible because of barriers associated with studying populations of workers. Well-designed prospective cohort studies (or nonrandomized trials) with a concurrent control group could inform the strength of evidence related to TWH interventions. Studies without a control group are unlikely to contribute significantly to an understanding of the strength of evidence supporting TWH interventions (because of the inherent bias in the design); these designs should be avoided.

Investigators should plan for high attrition (and differential attrition between intervention and control groups). In addition, they should use methods to address missing data when necessary; approaches such as imputation of missing data or use of a last observation carried forward method should be considered.

Studies should address baseline differences between groups (when they are present) using appropriate statistically methods. Furthermore, investigators should report measures of variance (e.g., confidence intervals) for all outcomes they evaluate. Finally, in reporting their studies, authors should highlight whether other (concurrent) OSH and HP policies or programs had been in place or implemented during the intervention in question; this will enable them to assess bias associated with contamination.

Findings in Relation to What Is Already Known

This is an emerging body of literature; we did not find a previous systematic review that was similar in scope or that assessed the SOE related to common outcomes reported in studies of TWH interventions. We identified one prior systematic review¹⁸ and one expert (or narrative) review¹⁷ that provided a broad overview of TWH interventions.

The results of our current review are, in general, consistent with those in previous reviews with respect to conclusions about the limitations of the evidence base. For example Anger and colleagues noted that integrated interventions improved risk factors for chronic diseases. They concluded, however, that the evidence that integration itself confers a significant benefit is lacking and is “perhaps the most glaring gap in the TWH literature.”¹⁸

Like previous reviews, we took a broad approach to defining “integration.” Not surprisingly, our review and the two earlier reviews differ slightly in terms of included studies and whether we considered them integrated or not. For example, one study assessing a worksite wellness program designed for firefighters was included in the review by Anger and colleagues; we excluded this study because it had no explicit coordination between OSH and HP programs and no obvious OSH content or focus of the intervention.⁷² We also excluded studies evaluating “sit-stand” workstations only (with no explicit coordination with HP activities or promotion of physical activity outside of work).⁷³

Our review differs from others in terms of methods. Prior reviews have either not addressed potential bias associated with TWH interventions or used study design labels as a proxy for assessment of the risk of bias of included studies.¹⁸ We used standard techniques for assessing risk of bias for individual trials or observational studies (documented in Appendix C) and grading the SOE for entire bodies of evidence (Appendix D).

Moreover, in terms of overall conclusions about the effectiveness of TWH interventions, our review differs in that we assessed the SOE for specific outcomes. Prior reviews have made generalized statements about the positive effects of TWH interventions or have summarized the

benefits primarily by noting the number of statistically significant outcomes found across studies; they generally have not considered the consistency or precision associated with findings.^{17,18} In general, the two prior reviews make stronger conclusions regarding the benefits of integrated integration than we reached.

Applicability

During our review process, we systematically abstracted key factors that may affect the applicability of the evidence base. We identified these key factors a priori. We defined applicability according to AHRQ guidance: “the extent to which the effects observed in published studies are likely to reflect the expected results when a specific intervention is applied to the population of interest under real-world conditions.”²⁴ For this review, we focused on issues that relate to populations of workers and worksites in the United States.

Approximately one-half of the studies we included had been conducted in this country; the others were conducted in European or Scandinavian countries. Included studies focused primarily on populations employed either in the manufacturing or construction industries or in health care. Populations enrolled in included studies were generally between the ages of 30 and 50; the baseline comorbidity of workers was often not described. Results of included studies may not be applicable to workers who are very young or very old or who have a high burden of comorbid medical conditions. The proportion of workers who had access to medical care or other, ongoing worksite health programs was often not well described. Whether the results of included studies would apply to worksites that have established HP and OSH programs in place (whether or not they are integrated) remains unclear.

Studies that contributed to our SOE grades had all been conducted among US blue-collar workers (manufacturing worksites in the Massachusetts or unionized construction workers). The evidence for which we developed SOE grades is based on survey data collected before 2004 and comes from the same group of researchers.^{25,32,33,39} Within the past decade (i.e., since the mid-2000s), workplace HP and OSH programs have very likely been improved; whether the results of these trials would be applicable to worksites that already have active HP programs (or policies) that promote smoking cessation and healthy eating is not clear.

More recent changes in health policy or practice (such as community health interventions and health care) may limit the applicability of studies published 10 or more years ago. After the implementation of the Affordable Care Act, national surveys show improvements in self-reported health-care coverage, access to primary care and medications, greater affordability, and better health among younger populations of men (at least in states that expanded Medicaid coverage).⁷⁴ Access to smoking cessation services may be more widely available because of these changes; intervention components evaluated in older studies could now be considered “usual care” in some settings.

Implications for Employer and Policy Decisionmaking

The goals of the Pathways to Prevention program are to host workshops that identify research gaps in a selected scientific area (including methodological and scientific weaknesses), to suggest research needs, and to move the field forward through an unbiased, evidence-based assessment of a complex public health issue.¹⁹ This report describes the body of evidence supporting TWH interventions, lays out scientific and methodological weaknesses, and proposes future research needs based on gaps identified in the literature base during the evidence synthesis.

Although this evidence base is limited, we found evidence (low SOE) supporting integrated interventions in improving rates of smoking cessation over 22 to 26 weeks and consumption of fruit and vegetables over 26 to 104 weeks. These interventions had specific characteristics that should be taken into consideration in future research or by employers who want to improve evidence-based integrated strategies. However, due to the limited evidence base, it is not clear whether certain characteristics contributed to the efficacy of the intervention (or whether certain strategies are more or less effective for certain outcomes or subgroups of workers).

Specifically, all these effective interventions shared the following characteristics:

1. They were informed by worker participation in the development, design, planning, and/or implementation of the intervention.
2. They included comprehensive program content that highlighted the potential additive or synergistic risks of hazardous workplace exposures and health behavior.
3. Interventions had tailored intervention components or materials to various cultural or social aspects of the worker population (e.g., to workers with low literacy skills or those for whom English was not a first language)
4. Effective interventions are multicomponent, complex interventions that reinforce messages about behavior change through multiple levels of influence or multiple modes of delivery (or both) over time.

Limitations of the Review Process

We cast a broad net in terms of our inclusion criteria that relate to interventions. The studies that met our inclusion criteria used a range of strategies to address both HP and OSH concerns. Included studies were often published before the terms “integrated intervention” or “total worker health” were used to describe interventions. Because of a lack of consistent terminology related to “integration” and (potentially) inadequate reporting or description of intervention components in some studies, we may have overlooked some interventions that could be considered integrated. This was also a limitation in terms of synthesizing the evidence across complex interventions which utilize various approaches to addressing OSH and HP. Our inclusion criteria for interventions is based on the definition of a TWH program from the National Institute of Occupational Safety and Health for “Total Worker Health” and other, related guidance on integration.⁹

Our searches were based on studies generally considered to be focused on integration; however, these studies are not indexed by standard or consistent terms that are specific to integration or TWH. To address this deficiency, we solicited and received a database from NIOSH that listed studies deemed relevant to TWH. Our search strategies had identified the vast majority of these studies. Nevertheless, some studies that we excluded might still be considered related to TWH. All in all, therefore, whether certain types of interventions are considered integrated remains inconsistent. As noted previously, our review and two other prior reviews differed slightly in terms of included studies; for example, we excluded at least three studies found in those prior reviews as “wrong intervention” because they primarily addressed HP only or OSH only.⁷⁵⁻⁷⁷

Publication bias and selective reporting of outcomes are potential limitations. Although we searched for unpublished trials and unpublished outcomes, we did not find direct evidence of either of these biases. Many of the included trials were published before trial registries (e.g., clinicaltrials.gov) became available; had we been able to consult such registries, we would have had greater certainty about the potential for either type of bias.

Finally, for this review, we excluded non-English-language studies based largely on limitations of time and resources. However, we identified non-English language studies in our searches and did not see any references that had the potential to be useful in this review. Searches of the NIOSH references did not uncover any non-English studies. Given this, and the fact that TWH is a relatively new strategy, we believe that limiting our review to English-language studies had little effect.

Limitations of the Evidence Base

The evidence base assessing TWH interventions was limited in scope and volume. It was inadequate to draw conclusions for some of our questions or subquestions of interest. Authors of different studies did not usually report the same outcomes or assess similar intervention types. Because of gaps in the trial evidence and because conducting trials in workplace settings is challenging, we included observational studies in this review.

For KQ 2, we limited our synthesis to studies with a concurrent control group. Studies with a pre-post comparison only generally do not provide valid and useful information to address questions of the benefits and harms of interventions. We did include pre-post studies to inform the assessment of gaps and future research needs – primarily in terms of describing gaps in the types of populations and interventions assessed in prior studies. Limiting by study design is unlikely to have had a major effect in terms of our assessment of the strength of evidence.

Among studies eligible for KQ 2, many had methodological limitations introducing significant risk of bias. The major problems across studies relate to selection bias and attrition bias. These are described above under the section on research gaps (methodological limitations). Briefly, many studies relied on surveys to assess improvements in worker health; nonresponse bias is a concern. Overall attrition in studies was often high. For the 10 studies that had very high overall attrition (>20 percent), high differential attrition (>15 percent), or both, only one of these studies employed methods to address missing data⁴³ (e.g., last observation carried forward). Most trials analyzed only completers and did not use any methods to address missing data.

Among other problems seen (even in studies with medium risk of bias overall), we noted especially the following: no reporting of randomization and allocation concealment; difference in intervention and control groups at baseline; small sample sizes (and thus lack of power for determining intended effects); and lack of clarity in defining intervention components. Finally, studies often lacked of information on statistical methods (or data on confidence intervals or similar information on statistical tests).

Conclusions

Overall, we found the body of evidence to be small, heterogeneous in terms of populations, interventions, and measured outcomes, and, in some areas of interest, nonexistent. The small size of the body of evidence is not altogether surprising given that the concept of “integration” is relatively new. The body of evidence may reasonably be expected to grow over the next few years. Evidence of low SOE supported the effectiveness of TWH interventions for improving rates of smoking cessation over 22 to 26 weeks and increasing the consumption of fruit and vegetable intake over 26 to 104 weeks compared with no intervention. Evidence was insufficient to assess the effectiveness of integrated interventions for improving levels of physical activity or decreasing the intake of red meat. Effective interventions were informed by worker participation and included comprehensive program content that highlighted the potential additive or synergistic risks of hazardous workplace exposures and health behavior. The applicability of

these findings is limited; most trials enrolled blue-collar workers (from manufacturing worksites in Massachusetts or unionized construction workers) before 2004.

Additional adequately powered multi-site RCTs or other prospective studies with a concurrent control are needed to replicate encouraging findings that have been observed to date in only a few trials. Investigators also need to design studies explicitly to assess the benefits of integration alone (separate from new HP or OSH components). Including a broader range of workers in future studies could increase the applicability of TWH interventions and enable reviewers to assess the consistency of findings. It might also answer the question of whether integrated strategies are more effective (or not) in groups of workers who differ by demographic, social or occupational characteristics that contribute to risk adverse health outcomes.

References

1. Leigh JP, Markowitz SB, Fahs M, et al. Occupational injury and illness in the United States. Estimates of costs, morbidity, and mortality. *Arch Intern Med.* 1997 Jul 28;157(14):1557-68. PMID: 9236557.
2. Dembe AE. The social consequences of occupational injuries and illnesses. *Am J Ind Med.* 2001 Oct;40(4):403-17. PMID: 11598991.
3. Bureau of Labor and Statistics. Employer-Reported Workplace Injury and Illness Summary. Washington, DC: Bureau of Labor Statistics, U.S. Department of Labor; 2013 4 December, 2014. www.bls.gov/news.release/osh.nr0.htm. Accessed 16 December, 2014.
4. Mokdad AH, Marks JS, Stroup DF, et al. Actual causes of death in the United States, 2000. *JAMA.* 2004 Mar 10;291(10):1238-45. PMID: 15010446.
5. Hymel PA, Loeppke RR, Baase CM, et al. Workplace health protection and promotion: a new pathway for a healthier--and safer--workforce. *J Occup Environ Med.* 2011 Jun;53(6):695-702. PMID: 21654443.
6. Centers for Disease Control and Prevention. Total Worker Health™. Atlanta, GA: CDC; 2013 August 20. www.cdc.gov/niosh/twh/. Accessed December 16, 2014.
7. World Health Organization. Jakarta Statement on Healthy Workplaces. Geneva, Switzerland: World Health Organization; 1997 www.who.int/healthpromotion/conferences/previous/jakarta/statements/workplaces/en/. Accessed May 6, 2015.
8. National Institute for Occupational Safety and Health (NIOSH). Research Compendium: The NIOSH Total Worker Health™ Program: Seminal Research Papers. Publication No. 2012-146. Washington, DC: U.S. Department of Health and Human Services PHS, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH); May 2012.
9. Sorensen G, McLellan D, Dennerlein JT, et al. Integration of health protection and health promotion: rationale, indicators, and metrics. *J Occup Environ Med.* 2013 Dec;55(12 Suppl):S12-8. PMID: 24284762.
10. Okechukwu CA, Krieger N, Sorensen G, et al. MassBuilt: effectiveness of an apprenticeship site-based smoking cessation intervention for unionized building trades workers. *Cancer Causes Control.* 2009 Aug;20(6):887-94. PMID: 19301135.
11. Caspi CE, Dennerlein JT, Kenwood C, et al. Results of a pilot intervention to improve health and safety for health care workers. *J Occup Environ Med.* 2013 Dec;55(12):1449-55. PMID: 24270297.
12. Porru S, Donato F, Apostoli P, et al. The utility of health education among lead workers: the experience of one program. *Am J Ind Med.* 1993 Mar;23(3):473-81. PMID: 8503465.
13. McLellan D, Harden E, Markkanen P, et al. SafeWell Practice Guidelines: An Integrated Approach to Worker Health Version 2.0. Dana-Farber Cancer Institute, Inc Boston, MA: Harvard School of Public Health Center for Work HaW-b; September 2012. <http://centerforworkhealth.sph.harvard.edu/resources/safewell-resources>.
14. Center for the Promotion of Health in the New England Workplace, Healthy Workplace Participatory Program. CPH-NEW Healthy Workplace Participatory Program. Lowell, MA: UMASS Lowell www.uml.edu/Research/Centers/CPH-NEW/Healthy-Work-Participatory-Program/default.aspx. Accessed 27 July 2015.
15. Commission on Health and Safety and Workers Compensation. The Whole Worker. Guidelines for Integrating Occupational Health and Safety with Workplace Wellness Programs. Commission on Health and

- Safety and Workers' Compensation
Oakland, CA: 2010.
www.dir.ca.gov/chswc/WOSHTEP/Publications/WOSHTEP_TheWholeWorker.pdf.
16. Institute of Medicine. Integrating Employee Health: A Model Program for NASA. Washington, DC: National Academy of Sciences; 2005 September 4, 2013.
<http://iom.nationalacademies.org/Reports/2005/Integrating-Employee-Health-A-Model-Program-for-NASA.aspx>. Accessed 27 July 2015.
 17. Pronk NP. Integrated worker health protection and promotion programs: overview and perspectives on health and economic outcomes. *J Occup Environ Med*. 2013 Dec;55(12 Suppl):S30-7. PMID: 24284747.
 18. Anger WK, Elliot DL, Bodner T, et al. Effectiveness of Total Worker Health interventions. *J Occup Health Psychol*. 2015;20(2):226-47. PMID: 2014-55995-001.
 19. National Institutes of Health. Pathways to Prevention Program. Bethesda, MD: Division of Program Coordination, Planning, and Strategic Initiatives, National Institutes of Health 2015 February 26, 2015.
<https://prevention.nih.gov/programs-events/pathways-to-prevention>. Accessed March 8, 2015.
 20. United Nations Development Programme (UNDP). Human Development Report 2014 - Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience. UNDP; 2014 <http://hdr.undp.org/en/2014-report>.
 21. Systematic Review Data Repository. Accessed at <http://srd.ahrq.gov/> (June 30, 2015).
 22. Agency for Healthcare Research and Quality. Methods Guide for Effectiveness and Comparative Effectiveness Reviews. Agency for Healthcare Research and Quality AHRQ Publication No. 10(14)-EHC063-EF. Rockville, MD: January 2014. Chapters available at:
www.effectivehealthcare.ahrq.gov.
 23. Berkman ND, Lohr KN, Ansari MT, et al. Grading the strength of a body of evidence when assessing health care interventions: an EPC update. *J Clin Epidemiol*. 2014 Dec 20; PMID: 25721570.
 24. Atkins D, Chang SM, Gartlehner G, et al. Assessing applicability when comparing medical interventions: AHRQ and the Effective Health Care Program. *J Clin Epidemiol*. 2011 Nov;64(11):1198-207. PMID: 21463926.
 25. Sorensen G, Stoddard AM, LaMontagne AD, et al. A comprehensive worksite cancer prevention intervention: behavior change results from a randomized controlled trial (United States). *J Public Health Policy*. 2003;24(1):5-25. PMID: 12760241.
 26. Lamontagne AD, Stoddard AM, Youngstrom RA, et al. Improving the prevention and control of hazardous substance exposures: a randomized controlled trial in manufacturing worksites. *Am J Ind Med*. 2005 Oct;48(4):282-92. PMID: 16142731.
 27. Hunt MK, Lederman R, Stoddard AM, et al. Process evaluation of an integrated health promotion/occupational health model in WellWorks-2. *Health Educ Behav*. 2005 Feb;32(1):10-26. PMID: 15642751.
 28. Maes S, Verhoeven C, Kittel F, et al. Effects of a Dutch work-site wellness-health program: the Brabantia Project. *Am J Public Health*. 1998 Jul;88(7):1037-41. PMID: 9663150.
 29. Palumbo MV, Wu G, Shaner-McRae H, et al. Tai Chi for older nurses: a workplace wellness pilot study. *Appl Nurs Res*. 2012 Feb;25(1):54-9. PMID: 20974089.
 30. Blackburn J, Brumby S, Willder S, et al. Intervening to improve health indicators among Australian farm families. *J Agromedicine*. 2009;14(3):345-56. PMID: 19657884.
 31. Tveito TH, Eriksen HR. Integrated health programme: a workplace randomized controlled trial. *J Adv Nurs*. 2009 Jan;65(1):110-9. PMID: 19032505.

32. Sorensen G, Barbeau EM, Stoddard AM, et al. Tools for health: the efficacy of a tailored intervention targeted for construction laborers. *Cancer Causes Control*. 2007 Feb;18(1):51-9. PMID: 17186421.
33. Sorensen G, Barbeau E, Stoddard AM, et al. Promoting behavior change among working-class, multiethnic workers: results of the healthy directions--small business study. *Am J Public Health*. 2005 Aug;95(8):1389-95. PMID: 16006422.
34. Hunt MK, Barbeau EM, Lederman R, et al. Process evaluation results from the Healthy Directions-Small Business study. *Health Educ Behav*. 2007 Feb;34(1):90-107. PMID: 16740502.
35. Barbeau E, Roelofs C, Youngstrom R, et al. Assessment of occupational safety and health programs in small businesses. *Am J Ind Med*. 2004 Apr;45(4):371-9. PMID: 15029570.
36. Nieuwenhuijsen ER. Health behavior change among office workers: an exploratory study to prevent repetitive strain injuries. *Work*. 2004;23(3):215-24. PMID: 15579930.
37. Hodges LC, Harper TS, Hall-Barrow J, et al. Reducing overall health care costs for a city municipality: a real life community based learning model. *AAOHN J*. 2004 Jun;52(6):247-53. PMID: 15219111.
38. Allen HM, Jr., Borden St, Pikelny DB, et al. An intervention to promote appropriate management of allergies in a heavy manufacturing workforce: evaluating health and productivity outcomes. *J Occup Environ Med*. 2003 Sep;45(9):956-72. PMID: 14506339.
39. Sorensen G, Stoddard A, Hunt MK, et al. The effects of a health promotion-health protection intervention on behavior change: the WellWorks Study. *Am J Public Health*. 1998 Nov;88(11):1685-90. PMID: 9807537.
40. Sorensen G, Stoddard A, Ockene JK, et al. Worker participation in an integrated health promotion/health protection program: results from the WellWorks project. *Health Educ Q*. 1996 May;23(2):191-203. PMID: 8744872.
41. Sorensen G, Himmelstein JS, Hunt MK, et al. A model for worksite cancer prevention: integration of health protection and health promotion in the WellWorks Project. *Am J Health Promot*. 1995 Sep-Oct;10(1):55-62. PMID: 10155659.
42. Boggild H, Jeppesen HJ. Intervention in shift scheduling and changes in biomarkers of heart disease in hospital wards. *Scand J Work Environ Health*. 2001 Apr;27(2):87-96. PMID: 11409601.
43. Eriksen HR, Ihlebaek C, Mikkelsen A, et al. Improving subjective health at the worksite: a randomized controlled trial of stress management training, physical exercise and an integrated health programme. *Occup Med (Lond)*. 2002 Oct;52(7):383-91. PMID: 12422025.
44. Olson R, Wright RR, Elliot DL, et al. The COMPASS pilot study: a total worker Health intervention for home care workers. *J Occup Environ Med*. 2015 Apr;57(4):406-16. PMID: 25654631.
45. Olson R, Anger WK, Elliot DL, et al. A new health promotion model for lone workers: results of the Safety & Health Involvement For Truckers (SHIFT) pilot study. *J Occup Environ Med*. 2009 Nov;51(11):1233-46. PMID: 19858740.
46. Wipfli B, Olson R, Koren M. Weight-loss maintenance among SHIFT pilot study participants 30-months after intervention. *J Occup Environ Med*. 2013 Jan;55(1):1-3. PMID: 23291953.
47. Maniscalco P, Lane R, Welke M, et al. Decreased rate of back injuries through a wellness program for offshore petroleum employees. *J Occup Environ Med*. 1999 Sep;41(9):813-20. PMID: 10491798.
48. Barbeau EM, Li Y, Calderon P, et al. Results of a union-based smoking cessation intervention for apprentice iron workers (United States). *Cancer Causes Control*. 2006 Feb;17(1):53-61. PMID: 16411053.
49. von Thiele Schwarz U, Augustsson H, Hasson H, et al. Promoting employee health by integrating health protection, health promotion, and continuous improvement: a

- longitudinal quasi-experimental intervention study. *J Occup Environ Med*. 2015 Feb;57(2):217-25. PMID: 25654524.
50. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement. *Open Med*. 2009;3(3):21.
 51. Olson R, Elliot D, Hess J, et al. The COMmunity of Practice And Safety Support (COMPASS) Total Worker Health study among home care workers: study protocol for a randomized controlled trial. *Trials*. 2014;15:411. PMID: 25348013.
 52. Strzelczyk JJ, Damilakis J, Marx MV, et al. Facts and controversies about radiation exposure, part 2: low-level exposures and cancer risk. *J Am Coll Radiol*. 2007 Jan;4(1):32-9. PMID: 17412222.
 53. Hunt MK, Harley AE, Stoddard AM, et al. Elements of external validity of tools for health: an intervention for construction laborers. *Am J Health Promot*. 2010 May-Jun;24(5):e11-20. PMID: 20569107.
 54. Dain SJ, Ngo TP, Cheng BB. Impact resistance and prescription compliance with AS/NZS 1337.6:2010. *Clin Exp Optom*. 2013 Sep;96(5):472-8. PMID: 23211031.
 55. Vyth EL, Steenhuis IH, Heymans MW, et al. Influence of placement of a nutrition logo on cafeteria menu items on lunchtime food Choices at Dutch work sites. *J Am Diet Assoc*. 2011 Jan;111(1):131-6. PMID: 21185975.
 56. Bennett JB, Patterson CR, Reynolds GS, et al. Team awareness, problem drinking, and drinking climate: workplace social health promotion in a policy context. *Am J Health Promot*. 2004 Nov-Dec;19(2):103-13. PMID: 15559710.
 57. Jmker SI, Blatter BM, van der Beek AJ, et al. Prospective research on musculoskeletal disorders in office workers (PROMO): study protocol. *BMC Musculoskelet Disord*. 2006;7:55. PMID: 16822300.
 58. Lerner D, Amick BC, 3rd, Rogers WH, et al. The Work Limitations Questionnaire. *Med Care*. 2001 Jan;39(1):72-85. PMID: 11176545.
 59. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav*. 1983 Dec;24(4):385-96. PMID: 6668417.
 60. Gray-Toft P, Anderson J. The Nursing Stress Scale: Development of an instrument. *J Behav Assess*. 1981 1981/03/01;3(1):11-23.
 61. Eriksen HR, Ihlebaek C, Ursin H. A scoring system for subjective health complaints (SHC). *Scand J Public Health*. 1999 Mar;27(1):63-72. PMID: 10847674.
 62. Bureau of Labor and Statistics. Occupational Injuries and Illnesses (Annual) News Release. 11/07/2013 News Release: Workplace Injuries and Illnesses-2012. Washington, DC: U.S. Department of Labor, Bureau of Labor and Statistics; 2013 November 7. www.bls.gov/news.release/archives/osh_11072013.htm. Accessed 10 August 2015.
 63. Bureau of Labor and Statistics. Employment by Major Occupational Group. Washington, DC: Bureau of Labor Statistics, U.S. Department of Labor; 2012 19 December, 2013. http://www.bls.gov/emp/ep_table_101.htm. Accessed 10 August, 2015.
 64. Bureau of Labor and Statistics. Nonfatal Occupational Injuries and Illnesses Requiring Days Away From Work, 2013. For release December 16, 2014. USD-14-2246. Washington, DC: U.S. Department of Labor, Bureau of Labor and Statistics; 2014 December 16 www.bls.gov/news.release/osh2.nr0.htm. Accessed 10 August 2015.
 65. Loomis D, Schulman MD, Bailer AJ, et al. Political economy of US states and rates of fatal occupational injury. *Am J Public Health*. 2009 Aug;99(8):1400-8. PMID: 19542025.
 66. Jamal A, Agaku IT, O'Connor E, et al. Current cigarette smoking among adults--United States, 2005-2013. *MMWR Morb*

- Mortal Wkly Rep. 2014 Nov 28;63(47):1108-12. PMID: 25426653.
67. Centers for Disease Control and Prevention. Subjects of Interest to Total Worker Health™. Atlanta, GA: Centers for Disease Control and Prevention; 2013. Accessed 10 August 2015.
 68. National Institute for Occupational Safety and Health (NIOSH). NIOSH, Hierarchy of Controls. Washington, DC: Centers for Disease Control and Prevention; 2015 January 13. www.cdc.gov/niosh/topics/hierarchy/ Accessed 10 August 2015.
 69. Community Preventive Services Task Force. Recommendations for worksite-based interventions to improve workers' health. Am J Prev Med. 2010 Feb;38(2S):S232-6.
 70. Schulz KF, Altman DG, Moher D, et al. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. BMJ. 2010;340:c332. PMID: 20332509.
 71. Taljaard M, Weijer C, Grimshaw JM, et al. The Ottawa Statement on the ethical design and conduct of cluster randomised trials: precis for researchers and research ethics committees. BMJ. 2013;346:f2838. PMID: 23661113.
 72. Elliot DL, Goldberg L, Kuehl KS, et al. The PHLAME (Promoting Healthy Lifestyles: Alternative Models' Effects) firefighter study: outcomes of two models of behavior change. J Occup Environ Med. 2007 Feb;49(2):204-13. PMID: 17293760.
 73. Pronk NP, Katz AS, Lowry M, et al. Reducing occupational sitting time and improving worker health: the Take-a-Stand Project, 2011. Prev Chronic Dis. 2012;9:E154. PMID: 23057991.
 74. Sommers BD, Gunja MZ, Finegold K, et al. Changes in Self-reported Insurance Coverage, Access to Care, and Health Under the Affordable Care Act. JAMA. 2015 Jul 28;314(4):366-74. PMID: 26219054.
 75. Alkhajah TA, Reeves MM, Eakin EG, et al. Sit-stand workstations: a pilot intervention to reduce office sitting time. Am J Prev Med. 2012;43:298-303.
 76. Ott MG, Yong M, Zober A, et al. Impact of an occupational health promotion program on subsequent illness and mortality experience. Int Arch Occup Environ Health. 2010 Dec;83(8):887-94. PMID: 20186547.
 77. Hall J, Mansfield L, Kay T, et al. The effect of a sit-stand workstation intervention on daily sitting, standing and physical activity: protocol for a 12 month workplace randomised control trial. BMC Public Health. 2015;15:152. PMID: 25879905.
 78. Centers for Disease Control and Prevention. The National Institute for Occupational Safety and Health (NIOSH): About NIOSH Atlanta, GA: Centers for Disease Control and Prevention; 2013 <http://www.cdc.gov/niosh/about.html>. Accessed 30 July 2015.
 79. World Health Organization Programme on Mental Health. Measuring quality of life: The World Health Organization quality of life instruments. Geneva, Switzerland: World Health Organization; 1997.
 80. Eriksson I, Unden AL, Elofsson S. Self-rated health. Comparisons between three different measures. Results from a population study. Int J Epidemiol. 2001 Apr;30(2):326-33. PMID: 11369738.
 81. van der Laan L, van Spaendonck K, Horstink MW, et al. The Symptom Checklist-90 Revised questionnaire: no psychological profiles in complex regional pain syndrome-dystonia. J Pain Symptom Manage. 1999 May;17(5):357-62. PMID: 10355214.

TWH Glossary of Terms

Term or Scale	Definition
Medical Outcomes Study Short Form Health Survey with 36 items (SF-36)	QOL measure with a range of scores from 0-100, with increasing scores indicating improvement.
Medical Outcomes Study Short Form with 12 items (SF-12)	Shorter version of the SF-36 instrument. Also uses a range of scores from 0-100, with increasing scores indicating improvement.
National Institute for Occupational Safety and Health (NIOSH)	The U.S. federal agency that conducts research and makes recommendations to prevent worker injury and illness. NIOSH provides the only dedicated federal investment for research needed to prevent the societal cost of work-related fatalities, injuries and illnesses in the United States. ⁷⁸
Nursing Stress Scale (NSS)	Work-specific stress scale that assesses the frequency and the major sources of stress experienced by nurses on hospital units. Uses a range of total scores from 0-102, with higher scores indicating more frequent stress. ⁶⁰
Occupational Health and Safety (OHS) components	Intervention (or program) components aimed at reducing hazardous exposures at work that can lead to work-related injury, illness and disability. Interventions can be at the organizational or individual level (or both). Examples include (but are not limited to) the following: employer policies to improve (or remove) work hazards; engineering controls designed to eliminate or substitute hazards; adoption of improved personal protective equipment; individual-level health and safety training to employees.
Pathways to Prevention (P2P) Program	Program led by the National Institutes of Health (NIH) to host workshops that identify research gaps in a selected scientific area, identify methodological and scientific weaknesses in that scientific area, suggest research needs, and move the field forward through an unbiased, evidence-based assessment of a complex public health issue. ¹⁹
Perceived Stress Scale (PSS)	Scale that measures general levels of psychological stress, with higher scores indicating more stress. ⁵⁹
Quality of life (QOL)	A multidimensional, broad-ranging concept that can be defined as an individual's perception of their position in life in the context of the culture and value systems in which they live. Factors such as physical health, mental health, and social relationships can affect a person's QOL. ⁷⁹
Self-rated health (SRH) Inventory	Contains a single five-point item asking respondents to rate their current health status compared with others of the same age, with higher scores indicating worse self-ratings of health. ⁸⁰
Symptom Checklist-90 (SCL-90)	A self-report inventory used to evaluate levels of psychiatric symptomatology, such as anxiety, depression, somatic complaints, hostility, and sleep problems. ⁸¹ A decrease from baseline indicates improvement in levels of stress. Higher scores on this scale indicate more stress.
Total Worker Health™ (TWH)	The “strategic and operational coordination of policies, programs, and practices designed to simultaneously prevent work-related injuries and illnesses, and enhance overall workforce health and well-being.” ⁹ Total Worker Health™ is a trademarked term first used by NIOSH in 2011 for an initiative focusing attention on integrated approaches to protecting and promoting health. ⁶
Work Life Questionnaire (WLQ)	A measure of work-specific functioning that assesses the degree to which health problems interfere with the ability to perform job roles. Specifically, it asks about the ability to perform 25 specific job demands within the past 2 weeks; lower scores indicate improvement in ability to perform job demands. ⁵⁸
Worksite Health Promotion (HP) components	Intervention (or program) components aimed at promoting worker health through reduction of individual risk-related behaviors such as tobacco use, substance use, sedentary lifestyle, poor nutrition, stressors, and other preventable health behaviors. Intervention components may incorporate employee assistance programs, clinical prevention services, disease management programs and other health benefits. Interventions may also include community-based services (e.g., referral for community-based health services) or environmental changes (e.g., increasing access to health foods at a worksite)